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V.—ON THE CHEMISTRY OF FISH.

PART I.—ANALYSES OF SPECIMENS OF AMERICAN FISHES.

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[Concluded from Vol. IX, No. 6, p. 452.]

The desirability of more information as to the proximate composition of the flesh of fish led to a number of analyses in accordance with the methods described in the chapter on Methods of Analysis. They are very nearly the same as were followed by Almén,[1] who has made a number of analyses of the flesh of fish. His results, with those of Kostytschef, whom I infer to have worked by similar methods, are to be recapitulated in an account of European analyses of fish, to follow.

Table V gives the proportions of proximate ingredients in the water-free substance of the flesh of American fishes as directly determined; that is to say, it recapitulates the determinations of extractive matters, albumen, gelatin, insoluble protein, etc., as made in accordance with the statements in the chapter on Methods of Analysis. The figures for ether extract and ash are those of the previous tables. As there stated, I do not consider the determinations of the nitrogenous constituents entirely accurate. The methods are not yet well enough worked up to give satisfactory results. The figures will, however, serve for comparison with those

[1] Loc. cit.

obtained by Almén, and, I presume, with those of Kostytschef. It is to be noted, however, that the figures here given refer simply to the flesh, while those of Almén I understand to include the skin with the flesh, and presume that the same may be the case with Kostytschef's, though as to the latter point I am not definitely informed. The last column of Table V gives the sums of the several constituents. These vary more or less from 100 per cent., and thus indicate errors in the determination. Where these footings have varied by more than 5 per cent. from 100 per cent. in the water-free substance (which would correspond to from 1 per cent. to 2 per cent. in the fresh flesh), the insoluble protein for each specimen has been omitted from the table. The methods of estimating the extractive matters, gelatin, and insoluble protein differ in the different specimens with respect to the determinations of ash and fat, as indicated in the table, and stated in full in the details of the analyses which will be given in the monograph already referred to. I have deemed it proper to state the precise facts with reference to these analyses, so that they may be taken exactly for what they are worth. The analytical details will help in judging properly of their value. As stated in the description of the method of analysis, the methods were those laid down by other analysts. We followed those methods and did the work as faithfully as we were able. If the results have no other value, they at least show the need of working up the methods more thoroughly.

Table VI gives the proximate ingredients of the flesh as directly determined. The analyses are those of Table V calculated on fresh substance, the figures for water being those stated in previous tables.

Table VII states the percentages of phosphorus calculated as P_2O_5 and as PO_4, of sulphur as SO_3 and as SO_4, and of chlorine in both water-free substance and fresh substance of flesh. The determinations were made as described in the chapter on Methods of Analysis, and I believe them to be reasonably accurate.

Analyses of preserved fish are given in Tables VIII and IX, and explained in the chapter on Economic Results of Analyses, beyond. The composition of the specimens of fresh and preserved fish as received for analysis, including both flesh and other parts, is stated in Table X and explained in the same chapter.

TABLE V.

Composition of Water-free Substance of Flesh of Specimens of American Fishes. Proximate Ingredients as directly determined.

KIND OF FISH.	Laboratory Numbers of Specimens.	Extractive Matters, Cold-water Extract, not coagulated.	Albumen coagulated from Cold-water Extract.	Gelatin, Hot-water Extract.	Insoluble Protein.	Fats, Ether Extract.	Ash.	Total.
		per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.
Black bass	53	10.49[1]	9.54	14.48[1]	...	4.47	5.57	...
Black fish	38	7.46[1]	11.32	15.79[1]	51.00[1]	12.20	5.54	103.31
Common flounder	22	12.77[2]	6.51	24.07[2]	...	5.18	8.63	...
Haddock	21	6.18[2]	7.89	16.36[2]	65.06	0.78	8.72	104.99
Herring	47	4.51[1]	5.23	9.46[1]	...	35.55	4.83	...
Mascalonge	45	9.55[1]	6.95	10.20[1]	56.71[1]	10.70	6.63	100.74
Mackerel	30	8.61[1]	7.27	5.74[1]	47.37[2]	27.04	5.02	101.05
Spanish mackerel	43	6.96[1]	3.92	9.22[1]	...	29.56	4.71	...
White perch	44	6.76[1]	7.35	13.39[1]	...	23.07	4.56	...
"	46	8.88[1]	9.78	11.04[1]	51.47[1]	10.42	5.27	96.86
" Average of 2 specimens.		7.82[1]	8.57	12.22[1]	...	16.75	4.92	...
Pike perch, Wall-eyed pike	52	13.14[1]	5.87	16.98[1]	52.15[1]	2.31	6.75	97.20
Porgy	31	6.35[1]	10.64	7.41[1]	44.40[2]	28.04	4.81	101.65
Red snapper	20	8.38[2]	7.30	16.83[2]	60.84	2.85	5.82	102.02
"	26	8.16[2]	8.12	12.75[2]	56.09	8.58	5.86	99.56
" Average of 2 specimens.		8.27[2]	7.71	14.79[2]	58.46	5.72	5.84	100.79
California salmon	27	4.85[2]	4.21	4.74[2]	32.02	51.59	2.98	100.39
Shad	32	6.68[1]	6.57	6.63[1]	43.60[2]	34.50	4.58	102.56
Sheepshead	48	5.11[1]	7.11	11.98[1]	...	24.02	3.93	...
Smelt	23	16.23[1]	3.02	25.07[1]	37.50	9.76	10.08	101.66
Brook trout	24	11.44[1]	8.01	9.88[1]	55.74	11.61	6.33	103.01
Turbot	49	7.04[1]	0.42	12.89[1]	28.14[1]	50.36	4.47	103.32
SPENT FISH.								
Salmon, male	35	9.18[1]	4.69	9.66[1]	53.09[1]	17.66	4.51	98.79
" female	36	6.27[1]	4.59	13.92[1]	...	12.98	5.36	...
" Average of 2 specimens		7.73[1]	4.64	11.79	...	15.32	4.94	...
Land-locked salmon, male	40	9.18[2]	2.94	8.88[1]	...	18.12	5.76	...
" " female	41	10.56[2]	5.14	10.58[1]	...	9.36	5.76	...
" " Average of 2 specimens		9.87[2]	4.04	9.73[1]	...	13.74	5.76	...
PRESERVED FISH.								
Salt mackerel	42	6.17[1]	0.50	2.91[1]	26.81[1]	39.08	22.76	98.23
Salt cod	34	3.26[1]	1.07	10.38[1]	32.67[1]	0.53	53.82	101.73
"	37	2.50[1]	2.07	7.28[1]	36.92[1]	0.94	52.43	102.14
" Average of 2 specimens		2.88	1.57	8.83	34.80	0.73	53.12	101.94
Boned salt cod	25	7.01[2]	1.84	6.62[2]	32.81	0.71	50.72	99.71
Smoked halibut	28	5.60[2]	1.51	3.23[1]	26.57[2]	31.90	31.01	99.82
Smoked herring	33	13.04[1]	0.48	7.84[1]	33.14[2]	24.18	20.15	98.83
Canned salmon	29	14.21[2]	...	5.27[2]	42.44[2]	32.40	5.24	99.56

[1] Ash- and fat-free. [2] Ash-free.

TABLE VI.

Composition of Flesh of Specimens of American Fishes. Proximate Ingredients as directly determined.

NAMES OF FISH.	Laboratory Numbers of Specimens.	Water.	Extractive Matters. Cold water Extract, not coagulated.	Albumen, coagulated from Cold-water Extract.	Gelatin. Hot-water Extract.	Insoluble Protein.	Fats. Ether Extract.	Ash.	Total.
		per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.
Black bass	53	78.61	2.24[1]	2.04	3.10[1]	...	0.96	1.19	...
Black fish	38	76.95	1.72[1]	2.61	3.64[1]	11.76[1]	2.81	1.28	100.77
Common flounder	22	85.04	1.91[2]	0.98	3.60[2]	...	0.77	1.29	...
Haddock	21	82.03	1.11[2]	1.42	2.94[2]	11.70	0.14	1.57	100.91
Herring	47	69.03	1.40[1]	1.62	2.93[1]	...	11.01	1.50	...
Mascalonge	45	76.26	2.27[1]	1.65	2.40[1]	13.46	2.54	1.57	100.15
Mackerel	30	74.14	2.22[1]	1.88	1.48[1]	12.25[2]	6.99	1.30	100.26
Spanish mackerel	43	68.10	2.22[1]	1.25	2.94[1]	...	9.43	1.50	..
White perch	44	75.64	1.65[1]	1.79	3.27[1]	...	5.62	1.11	...
" "	46	75.77	2.22[1]	2.37	2.68[1]	12.47[1]	2.52	1.28	99.31
" " Average of 2 specimens		75.71	1.94[1]	2.08	2.98[1]	...	4.10	1.20	101.24
Pike perch, Wall-eyed pike	52	79.74	2.66[1]	1.19	3.44[1]	10.57[1]	0.47	1.37	99.44
Porgy	31	71.98	1.78[1]	2.98	2.07[1]	12.44[2]	7.86	1.35	100.46
Red snapper	20	78.22	1.81[1]	1.59	3.65[2]	13.25	0.62	1.27	100.41
" "	26	77.34	1.85[2]	1.84	2.89[2]	12.71	1.94	1.33	99.90
" " Average of 2 specimens		77.78	1.83[1]	1.72	3.27[2]	12.98	1.28	1.30	100.15
California salmon	27	62.68	1.81[1]	1.57	1.77[1]	11.95	19.25	1.11	100.14
Shad	32	70.75	1.92[1]	1.92	1.93[1]	12.74[2]	10.08	1.34	100.68
Sheepshead	48	72.01	1.44[1]	1.09	3.36[1]	...	6.72	1.10	...
Smelt	23	80.16	3.22[2]	0.60	4.97[2]	7.44	1.94	2.00	100.33
Brook trout	24	77.54	2.57[2]	1.80	2.22[2]	12.52	2.61	1.42	100.68
Turbot	49	71.39	2.01[1]	0.12	3.69[1]	8.05[1]	14.41	1.28	100.95
SPENT FISH.									
Salmon, male	35	75.27	2.27[1]	1.16	2.89[1]	13.13[1]	4.37	1.12	99.71
" female	36	78.20	1.37[1]	1.00	3.03[1]	...	2.83	1.17	...
" Average of 2 specimens		76.74	1.77	1.08	2.71	...	3.60	1.15	...
Land-locked salmon, male	40	77.88	2.03[2]	0.65	1.97[1]	...	4.01	1.27	...
" " female	41	79.20	2.20[2]	1.07	2.20[1]	...	1.95	1.20	...
" " Average of 2 specimens		78.54	2.11[2]	0.86	2.09[1]	...	2.98	1.24	...
PRESERVED FISH.									
Salt mackerel	42	42.19	3.57[1]	0.29	1.68[1]	15.49[1]	22.59	13.16	98.97
Salt cod	34	53.62	1.51[1]	0.50	4.79[1]	15.15[1]	0.25	24.96	100.78
"	37	53.54	1.16[1]	0.96	3.38[1]	17.17[1]	0.44	24.35	101.00
" Average of two specimens		54.58	1.34	0.73	4.03	16.16	0.35	24.65	100.89
Boned salt cod	25	54.35	3.20[2]	0.84	3.02[1]	14.98	0.32	23.15	99.86
Smoked halibut	28	57.06	2.74[2]	0.74	1.58[1]	13.01[2]	15.61	15.18	99.92
Smoked herring	33	34.55	8.53[1]	0.32	5.13[1]	21.69[2]	15.82	13.19	99.23
Canned salmon	29	65.86	4.85[2]	...	1.80[2]	14.49[2]	11.06	1.79	99.85

[1] Ash- and fat-free. [2] Ash-free.

TABLE VII.

Percentages of Phosphoric Acid, Sulphuric Acid, and Chlorine in Flesh of Specimens of American Fishes.

NAMES OF FISHES.	Laboratory Number of Specimen.	In Water-free Substance.					In Fresh Substance.				
		Phosphoric Acid		Sulphuric Acid.			Phosphoric Acid		Sulphuric Acid.		
		Total phosphorus calculated as P_2O_5.	Total phosphorus calculated as PO_4.	Total sulphur calculated as SO_3.	Total sulphur calculated as SO_4.	Chlorine.	Total phosphorus calculated as P_2O_5.	Total phosphorus calculated as PO_4.	Total sulphur calculated as SO_3.	Total sulphur calculated as SO_4.	Chlorine.
		per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.
Alewife	5	2.06	2.76	...	...	...	0.50	0.67	...	...	...
Black bass	53	2.04	2.73	4.14	4.97	..	0.44	0.59	0.89	1.07	..
Striped bass	7	2.51	3.36	..	...	...	0.53	0.71	...	...	...
"	19	2.16	2.89	2.28	2.73	...	0.44	0.59	0.46	0.55	...
" average of 2 specimens.		2.34	3.14	...	...	...	0.48	0.64	...	...	...
Black fish	38	2.24	3.00	1.97	2.36	1.03	0.52	0.70	0.46	0.55	0.23
Blue fish	12	2.93	3.93	...	...	...	0.63	0.84	...	...	...
Cod	3	2.19	2.93	...	...	..	0.36	0.48	...	...	...
"	11	3.18	4.26	...	...	...	0.53	0.71	...	...	...
" average of 2 specimens		2.69	3.60	...	...	...	0.45	0.60	...	...	...
Eel	14	1.70	2.28	...	...	...	0.51	0.68	...	...	...
Flounder	2	1.86	2.49	2.23	2.68	...	0.31	0.41	0.38	0.46	...
"	22	2.70	3.62	3.10	3.72	...	0.40	0.54	0.46	0.55	...
" average of 2 specimens.		2.28	3.06	2.67	3.20	...	0.36	0.48	0.42	0.50	...
Haddock	16	2.43	3.26	...	...	...	0.48	0.64	...	...	...
"	21	2.54	3.40	2.26	2.71	..	0.45	0.60	0.40	0.48	...
" average of 2 specimens		2.49	3.34	...	...	..	0.47	0.63	...	...	...
Halibut	1	2.11	2.83	2.11	2.53	...	0.44	0.59	0.44	0.53	...
"	9	1.51	2.02	...	...	...	0.43	0.58	...	...	...
" average of 2 specimens.		1.81	2.43	...	...	...	0.44	0.59	...	...	...
Herring	47	1.77	2.37	1.77	2.12	...	0.55	0.74	0.55	0.66	...
Mascalonge	45	2.21	2.96	1.55	1.86	...	0.52	0.70	0.37	0.44	...
Mackerel	8	2.26	3.03	...	...	..	0.47	0.63	...	...	..
"	13	2.43	3.26	..	...	...	0.63	0.84	...	...	...
"	30	2.16	2.89	1.68	2.02	...	0.56	0.75	0.43	0.52	...
"	39	1.60	2.14	1.42	1.70	0.68	0.58	0.78	0.51	0.61	0.24
" average of 4 specimens		2.11	2.83	1.55	1.86	...	0.56	0.75	0.47	0.56	...
Spanish mackerel	43	1.88	2.52	1.81	2.17	...	0.60	0.80	0.58	0.70	...
White perch	44	1.46	1.96	2.54	3.05	...	0.36	0.48	0.62	0.74	...
"	46	2.13	2.85	2.80	3.36	...	0.52	0.70	0.68	0.82	...
" average of 2 specimens.		1.79	2.40	2.67	3.20	...	0.44	0.59	0.65	0.78	...
Pike perch	52	2.24	3.00	4.43	5.32	...	0.45	0.60	0.90	1.08	...

TABLE VII.—*Concluded.*

NAMES OF FISHES.	Laboratory Number of Specimen.	In Water-free Substance.					In Fresh Substance.				
		Phosphoric Acid.		Sulphuric Acid.			Phosphoric Acid.		Sulphuric Acid.		
		Total phosphorus calculated as P_2O_5.	Total phosphorus calculated as PO_4.	Total sulphur calculated as SO_3.	Total sulphur calculated as SO_4.	Chlorine.	Total phosphorus calculated as P_2O_5.	Total phosphorus calculated as PO_4.	Total sulphur calculated as SO_3.	Total sulphur calculated as SO_4.	Chlorine.
		per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.
Porgy	15	3.04	4.07	...	...	...	0.62	0.83	...	...	...
"	31	1.98	2.65	1.84	2.21	...	0.56	0.75	0.52	0.62	...
" average of 2 specimens		2.51	3.36	..	...	...	0.59	0.79	...	..	...
Red snapper	20	2.15	2.88	2.19	2.63	...	0.47	0.63	0.47	0.56	...
"	26	2.10	2 81	2.06	2.47	...	0.48	0.64	0.46	0.55	...
" average of 2 specimens.		2.13	2.85	2.13	2.56	...	0.47	0.63	0.47	0.56	...
Salmon	14	1.79	2.40	...	...	...	0.59	0.79	...	...	...
"	27	1.86	2.49	1.14	1.37	...	0.69	0.92	0.43	0.52	...
Spent salmon, male	35	1.89	2.53	1.58	1.90	0.74	0.47	0.63	0.39	0.47	0.18
" female	36	2.20	2.95	1.45	1.74	0.85	0.48	0.64	0.32	0.38	0.18
" average of 2 specimens.		2.05	2.75	1.52	1.82	0.80	0.48	0.64	0.36	0.43	0.18
Spent salmon, land-locked, male	40	2.31	3.10	1.77	2.12	0.95	0.51	0.68	0.39	0.47	0.21
" " female	41	2.43	3.26	1.98	2.38	0.93	0.51	0.68	0.41	0.49	0.19
" " average of 2 specimens.		2.37	3.18	1.88	2.26	0.94	0.51	0.68	0.40	0.48	0.20
Shad	10	1.94	2.60	...	...	...	0.67	0.90	...	...	...
"	32	1.76	2.36	1.78	2.14	0.74	0.52	0.70	0.52	0.62	0.22
" average of 2 specimens.		1.85	2.48	...	...	...	0.69	0.80	...	...	...
Sheepshead	48	1.62	2.17	1.71	2.05	...	0.45	0.60	0.48	0.58	...
Smelt	23	4.10	5.49	2.79	3.35	...	0.81	1.08	0.55	0.66	...
Turbot	49	1.66	2.22	1.12	1.34	...	0.48	0.64	0.32	0.38	..
Lake trout	17	1.80	2.41	1.94	2.33	...	0.56	0.75	0.62	0.74	...
Brook trout	24	2.72	3.64	2 13	2.56	...	0.61	0.82	0.48	0.58	...
White fish	18	2.35	3.15	1.36	1.63	...	0.71	0.95	0.41	0.49	...
PRESERVED FISH.											
Salt mackerel	42	0.61	0.82	1.06	1.27	...	0.35	0.47	0.61	0.73	...
Salt cod	34	0.61	0.82	1.56	1.87	25.66	0.28	0.37	0.72	0.86	11.90
"	37	0.48	0.64	1.61	1.93	25.71	0.22	0.29	0.75	0.90	11.94
" average of 2 specimens		0.55	0.74	1.59	1.91	25.69	0.25	0.34	0.74	0.89	11.92
Boned salt cod	25	0.79	1.06	1.48	1.78	24.51	0.36	0.48	0.68	0.82	11.19
Smoked halibut	28	0.95	1.27	0.89	1.07	17.69	0.46	0.62	0.44	0.53	8.66
Smoked herring	33	1.28	1.72	1.89	2.27	11.01	0.84	1.12	1.24	0.29	7.21
Canned salmon	29	1.77	2.37	1.27	1.52	...	0.60	0.80	0.43	0.52	...

Other Analyses of American Fishes.

Prof. R. H. Chittenden has reported an analysis of the flesh of halibut, "a fresh sample obtained in the market."[1] The source of the specimen, the season in which it was taken, and the portion of the body used for analysis are not stated. It appears, however, to have been rather lean in comparison with the specimens of halibut above reported. To facilitate such comparison, I give the result in the forms followed in the tables here, basing the calculation on the averages of Prof. Chittenden's analyses, which from their close agreement, as well as from the context, I take to be duplicate determinations of the same specimen of flesh.

Composition of Flesh of Halibut.

In water-free substance ("flesh dried at 100° C.")

Nitrogen.	Protein, N × 6.25.	Fats.	Ash.	Protein (N × 6.25) + Fats + Ash.	Albuminoids, etc., by difference.
per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
11.68	73.00	7.12	6.35	86.47	86.53

In flesh ("fresh sample.")

Water.	Water-free substance.	Albuminoids, etc., by difference.	Fats.	Ash.	Nitrogen.	Protein, N × 6.25.	Water + Protein (N × 6.25) + Fats + Ash.
per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
82.88	17.12	14.77	1.27	1.08	2.01	12.56	97.79

The flesh in the fresh condition contained 0.37 per cent. of phosphorus. For the other details of the analyses there is scarcely place here.

Prof. G. H. Cook has reported an analysis of menhaden, *Brevoortia tyrannus*,[2] which was, however, made for the purpose of learning the value of the fish for fertilising the soil, and yielded no data that could well be utilised here. No other analyses of flesh of American food-fishes have come to my attention.

The limits of the present account and the desirability of reference to some of the other branches of the investigation and to

[1] Am. Jour. Sci. [3], **13**, 123.

[2] Geology of New Jersey, p. 498.

work in other similar lines, preclude detailed discussion of the analyses here. I will, however, call attention to a few facts and generalisations from them.

IV.—Classification of Fish by their Composition.

On the basis of the figures of Tables I, III, and X, I have attempted a classification of the specimens of American fish analysed, by their content of (1) flesh, (2) water-free substance in flesh, and (3) water and fats. With the following figures, the classifications will need no further explanation. Where more than one specimen was analysed the averages of the analyses are used. Of course, a satisfactory classification would require many more analyses. Nevertheless, these figures may be assumed to give a tolerably fair idea of the relative composition of the fish, or at least an approximation that may serve until more complete data are obtained. Accordingly, the exact order of the species in each of the groups in Tables XI, XII, and XIII must be regarded as by no means fixed, since further analyses would very likely give averages varying more or less from the results here tabulated.

In Table XI, the species of which entire specimens of fish were received for analysis, i. e. specimens from which no portion had been removed before weighing and preparing for analysis, are arranged in order from those with the largest to those with the smallest proportions of flesh. The data are from Tables I and X.

Table XI.

Classification of Fish by percentages of Flesh, chiefly Muscular Tissue, in Entire Body.

Species containing 60 per cent. or over of Flesh.

Number of specimens analysed.	Kinds of Fish.	Flesh.	Number of specimens analysed.	Kinds of Fish.	Flesh.
		p. ct			p. ct.
1	Spanish mackerel.....	65.4	1	Red snapper.....	60.0
4	Salmon.....	64.7			

TABLE XI.—*Continued.*

Species containing between 60 and 50 per cent. of Flesh.

Number of specimens analysed.	Kinds of Fish.	Flesh.	Number of specimens analysed.	Kinds of Fish.	Flesh.
2	Smelt	58.1	1	Herring	54.0
1	Pike (pickerel.)	57.3	2	Pickerel	52.9
1	Cisco	57.3	2	Spent land-locked salmon	52.7
1	Butter fish	57.2	1	Turbot	52.3
2	Spent salmon	56.4	3	Brook trout	51.9
5	Mackerel	55.4	1	Mascalonge	50.8
2	Pompano	54.5	2	Alewife	50.5
1	Lamprey eel	54.2			

Species containing between 50 and 40 per cent. inclusive, of Flesh.

7	Shad	49.9	1	Winter flounder.	43.8
1	Weak fish	48.1	1	Lake trout, "Mackinaw trout."	43.7
2	Cod	47.5	1	King fish	43.4
1	White fish	46.5	1	Pike perch, "Wall-eyed pike."	42.8
1	Small-mouthed black bass	46.4	1	Mullet	42.1
5	Striped bass	45.1	1	Tom-cod	40.1
1	Large-mouthed black bass	44.0	3	Porgy	40.0
1	Sea bass	43.9			

Species containing between 40 and 30 per cent. of Flesh.

2	Black fish	39.9	1	Red bass	36.5
2	White perch	37.5	1	Sheepshead	34.0
1	Yellow perch	37.3	1	Common flounder	33.2
1	Pike perch, Gray pike	36.8			

In Table XII, compiled from Table III, the species are grouped by the percentages of water-free substance in the flesh, from those with the most to those with the least water-free substance. Of course, those with the most water-free substance have the least water, and vice versa; hence the first in the list have the lowest percentages of water, and the last are the most watery.

TABLE XII.

Classification of Fish by Proportions of Water-free Substance in Flesh of Specimens Analysed.

Species containing over 30 per cent. of water-free substance.

Number of specimens analysed.	Kinds of Fish.	Water-free substance.	Number of specimens analysed.	Kinds of Fish.	Water-free substance.
		p. ct.			p. ct.
2	California salmon	36.4	1	Herring	31.0
5	Salmon	36.4	2	Lake trout	30.9
1	Spanish mackerel	31.9	1	White fish	30.2

TABLE XII.—*Continued.*

Species containing from 30 to 25 per cent. inclusive, of water-free substance.

Number of specimens analysed.	Kinds of Fish.	Water free substance.	Number of specimens analysed.	Kinds of Fish.	Water free substance.
		p.ct.			
1	Butter fish	30.0	6	Mackerel	26.6
7	Shad	29.4	2	Alewife	25.6
1	Lamprey eel	28.9	1	Small-mouthed black bass	25.2
1	Turbot	28.6	1	Mullet	25.1
2	Salt-water eel	28.4	3	Porgy	25.0
2	Pompano	27.2			

Species containing between 25 and 20 per cent. of water-free substance.

3	Halibut	24.6	1	Large-mouthed black bass	21.4
2	Sheepshead	24.5	1	Sturgeon	21.3
2	White perch	24.3	1	Weak fish	21.0
1	Pollock	24.0	4	Black fish	20.9
1	Cisco	23.9	2	Smelt	20.8
1	Mascalonge	23.7	1	King fish	20.8
2	Spent salmon	23.3	2	Yellow perch	20.8
6	Striped bass	22.3	1	Sea bass	20.7
3	Brook trout	22.3	2	Grouper	20.6
1	Blue fish	21.5	2	Pickerel	20.3
3	Red snapper	21.5	1	Pike perch, Wall-eyed pike	20.3
2	Spent land-locked salmon	21.5	1	Pike pickerel	20.2
1	Small-mouthed red horse	21.4			

Species containing between 20 and 15 per cent. of water-free substance.

1	Pike perch, Gray pike	19.2	1	Skate	17.9
1	Tom-cod	18.5	5	Cod	17.4
1	Red bass	18.4	1	Hake	16.9
4	Haddock	18.3	2	Common flounder	15.8
1	Cusk	18.0	1	Winter flounder	15.7

Table XIII, likewise from Table III, gives a grouping of the species by the proportions of fat (ether extract) in the specimens analysed. They are arranged in order from those with the most to those with the least fat in the flesh. The proportions of water are also given to illustrate the principle, to be discussed in another place, that, as a rule, the percentage of water in the muscular tissue diminishes as that of fat increases, and vice versa. In general the fattest species have the most water-free substance.

Table XIII.

Classification of Fish by Proportions of Fat in Flesh of Specimens Analysed.

Species containing over 5 per cent. of Fats.

Number of specimens analysed.	Kinds of Fish.	Water.	Fats.	Number of specimens analysed.	Kinds of Fish.	Water.	Fats.
		p. ct.	p. ct.			p. ct.	p. ct.
2	California salmon	63.6	17.9	1	Spanish mackerel	68.1	9.4
1	Turbot	71.4	14.4	2	Salt-water eel	71.6	9.1
5	Salmon	63.6	13.4	2	Pompano	72.8	7.6
1	Lamprey eel	71.1	13.3	6	Mackerel	73.4	7.1
2	Lake trout	69.1	11.4	1	White fish	69.8	6.5
1	Butter fish	70.0	11.0	3	Halibut	75.4	5.2
1	Herring	69.0	11.0	3	Porgy	75.0	5.1
7	Shad	70.6	9.5				

Species containing between 5 and 2 per cent. of Fats.

2	Alewife	74.4	4.9	6	Striped bass	77.7	2.8
1	Mullet	74.9	4.6	1	Mascalonge	76.3	2.5
2	White perch	75.7	4.1	1	Small-mouthed black bass	74.8	2.4
2	Sheepshead	75.6	3.7	1	Weak fish	79.0	2.4
2	Spent salmon	76.7	3.6	1	Small-mouthed red horse	78.6	2.4
1	Cisco	76.2	3.5	3	Brook trout	77.7	2.1
2	Spent land-locked salmon	78.5	3.0				

Species containing less than 2, the majority less than 1 per cent. of Fats.

1	Sturgeon	78.7	1.9	2	Common flounder	84.2	0.7
2	Smelt	79.2	1.8	2	Grouper	79.4	0.6
1	Skate	82.2	1.4	1	Pike pickerel	79.8	0.6
4	Black fish	79.1	1.4	1	Sea bass	79.3	0.5
1	Blue fish	78.5	1.3	1	Pike perch, Wall-eyed pike	79.7	0.5
3	Red snapper	78.5	1.0	2	Pickerel	79.7	0.5
1	Large-mouthed black bass	78.6	1.0	1	Red bass	81.6	0.5
1	King fish	79.2	1.0	1	Tom-cod	81.6	0.4
1	Pollock	76.0	0.8	5	Cod	82.6	0.4
2	Yellow perch	79.3	0.8	1	Winter flounder	84.4	0.4
1	Pike perch, Gray pike	80.9	0.8	4	Haddock	81.7	0.3
1	Hake	83.1	0.7	1	Cusk	82.0	0.2

Comparison of the above groupings with the classification by families as practised by ichthyologists shows no very definite connection between the two. For that matter there is perhaps no reason to expect any such connection.

TABLE VIII.

Composition of Water-free Substance of Flesh of American Specimens of Preserved Fish.

KIND OF FISH.	Laboratory Numbers of Specimens.	Nitrogen.	Protein, N × 6.25.	Fats. Ether Extract.	Crude Ash (including 1.5% Salt).	Protein (N × 6.25) + Fats + Ash.	Albuminoids, etc. (by difference).
		per ct.	per ct.	per ct.	per ct.	per ct.	per ct.
DRIED.							
Desiccated cod	79	14.72	92.00	2.24	9.78	104.02	87.98
SALTED.							
Mackerel	42	5.85	36.56	39.08	22.76	98.40	38.16
SALTED AND DRIED.							
Cod	34	8.58	53.63	0.53	53.82	107.98	45.65
"	37	8.91	55.69	0.94	52.43	109.06	46.63
" boned	25	9.20	57.50	0.71	50.72	108.93	48.57
Desiccated cod	80	13.04	81.50	5.54	13.40	100.44	81.06
SALTED, SMOKED AND DRIED.							
Haddock	88	13.58	84.88	0.62	13.10	98.60	86.28
Halibut	28	6.04	37.75	31.90	31.01	100.66	37.09
"	218	7.04	44.00	27.61	28.42	100.03	43.97
Herring	33	9.03	56.44	24.18	20.15	100.77	55.67
CANNED.							
Mackerel	94	9.87	61.68	27.28	10.17	99.13	62.55
Salmon	29	9.87	61.69	32.40	5.24	99.33	62.36
"	96	8.48	53.00	38.55	9.34	100.89	52.11
"	241	7.34	45.88	50.62	4.15	100.65	45.23
Sardines[1]	87	9.12	57.00	29.14	12.85	98.99	58.01
Tunny, "Horse mackerel"	240	12.72	79.50	14.84	6.19	100.53	78.97
Salt mackerel	55	4.68	29.25	49.22	21.09	99.56	29.69
" "	219	5.08	31.75	44.05	24.53	100.33	31.42
Smoked haddock	275	11.40	71.25	7.18	23.14	101.57	69.68

V.—ECONOMIC RESULTS OF ANALYSES.

As the object of the United States Fish Commission, at whose instance the present investigation was undertaken, was to obtain information of economic as well as purely scientific value, a number of analyses were made of the flesh of prepared fish. A few of the figures obtained were given in Tables IV, V, and VI. The principal results are included in Tables VIII and IX, which give data for the flesh of preserved fish similar to those for the flesh in its

[1] This specimen was, or at least purported to be, from France.

natural condition in Tables II and III. Although their value rests mainly upon what they show of the nutritive values, the replacement of the water in the flesh by salt is a matter of physiological interest. To estimate the percentage of salt, the total ash was determined, and the quantity properly belonging to the flesh calculated by assuming that its ratio to the sum of nitrogenous matters and fat would be the same as in the specimens of unsalted flesh of the same species. The mineral matter thus computed was subtracted from the total ash and the remainder taken as representing the amount of salt.

Table X gives the composition of the specimens of fish as received for analysis, including both flesh and refuse matters. The figures are computed from Tables I, III, and IX, the percentages of refuse and of constituents of flesh serving as the basis for the calculations. The figures for nitrogenous substances are reckoned by difference as explained in the discussion of Tables II and III. Deductions from these tables, concerning the nutritive values of fish, are to be given in the monograph referred to.

TABLE IX.

Composition of Flesh of American Specimens of Preserved Fish.

KIND OF FISH.	Laboratory Numbers of Specimens.	Water.	Water-free Substance.	Albuminoids, etc. (by difference).	Fats, Ether Extract.	Ash +	Salt +	Nitrogen.	Protein, N × 6.25.	Water + Protein (N × 6.25) + Fats + Ash + Salt.
DRIED.		per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.
Desiccated cod, "Evaporated fish"[1]	79	15.25	81.87	74.56	1.90	5.41	2.88	12.48	77.97	103.41
SALTED.										
Mackerel	42	42.19	47.21	22.06	22.59	2.56	10.60	3.38	21.14	99.08
SALTED AND DRIED.										
Cod	34	53.62	23.01	21.17	0.25	1.59	23.37	3.98	24.87	103.70
"	37	53.54	23.75	21.67	0.44	1.64	22.71	4.14	25.86	104.19
" Average of 2 specimens.		53.58	23.38	21.42	0.34	1.62	23.04	4.06	25.37	103.95
Boned cod, "Boneless codfish"	25	54.35	24.17	22.18	0.32	1.67	21.48	4.20	26.25	104.07
Desiccated cod, "Evaporated Fish"[1]	80	11.65	81.75	71.62	4.89	5.24	6.60	11.52	72.02	100.40
SALTED, SMOKED AND DRIED.										
Haddock	88	72.56	25.38	23.68	0.17	1.53	2.06	3.73	23.29	99.61
Halibut	28	51.06	35.89	18.15	15.61	2.13	13.05	2.96	18.49	100.34
"	218	47.70	39.43	23.00	14.44	1.99	12.87	3.68	23.01	100.01
" Average of 2 specimens		49.38	37.66	20.57	15.03	2.06	12.96	3.32	20.75	100.18
Herring	33	34.55	53.79	36.44	15.82	1.53	11.66	5.91	36.94	100.50
CANNED.										
Mackerel	94	68.18	29.89	19.91	8.68	1.30	1.93	3.14	19.63	99.72
Salmon	29	65.86	33.61	21.29	11.06	1.26	0.53	3.37	21.06	99.77
"	96	62.23	35.58	19.69	14.55	1.34	2.19	3.20	20.02	100.33
"	241	57.55	42.04	19.20	21.49	1.35	0.41	3.12	19.47	100.27
" Average of 3 specimens.		61.88	37.08	20 06	15.70	1.32	1.04	3.23	20.18	100.12
Sardines[2]	87	56.37	43.63	25.31	12.71	5.61	...	3.98	24.87	99.56
Tunny	240	72.74	27.26	21.52	4.05	1.69	...	3.47	21.67	100.15
Salt mackerel	95	43.23	47.33	16.86	27 94	2.53	9.44	2.66	16.60	99.74
" "	219	43.62	45.22	17.71	24.84	2.67	11.16	2.86	17.90	100.19
" " Average of 2 specimens.		43.43	46.27	17.28	26.39	2.60	10.30	2.76	17.35	99.97
Smoked haddock	275	68.73	25.68	21.78	2.25	1.65	5.59	3.58	22.29	100.51

[1] Flesh dried and ground. [2] French (?)

TABLE X.

Composition of American Fishes. Specimens as received for Analysis, including both Flesh (Edible Portion) and Refuse.

NAMES OF FISH AND PORTIONS ANALYSED.	Laboratory Numbers of Specimens.	Refuse: Entrails, Bones, Skin, etc.	Edible Portion. Flesh.	EDIBLE PORTION.				
				Water.	Water-free Substance (Nutrients.)	Nutrients.		
						Albuminoids (by difference).	Fats.	Mineral Matters.
FRESH FISH.		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Sturgeon, section of anterior part of body	238	14.4	85.6	67.4	18.2	15.4	1.6	1.2
Small-mouthed red horse, entrails removed	258	52.5	47.5	37.3	10.2	8.5	1.1	0.6
Herring, whole	47	46.0	54.0	37.3	16.7	10.0	5.9	0.8
Alewife, whole	5	49.5	50.5	38.3	12.2	9.5	1.9	0.8
" "	220	49.4	50.6	36.9	13.7	9.9	3.0	0.8
" " Average of 2 specimens		49.5	50.5	37.5	13.0	9.7	2.5	0.8
Shad, whole	6	49.3	50.7	35.3	15.4	9.2	5.5	0.7
" "	10	46.4	53.6	35.0	18.6	10.5	7.3	0.8
" "	32	45.9	54.1	38.3	15.8	9.6	5.5	0.7
" "	212	44.4	55.6	39.5	16.1	9.9	5.7	0.5
" "	221	53.2	46.8	33.7	13.1	9.3	3.1	0.7
" "	245	52.7	47.3	34.1	13.2	8.6	3.8	0.8
" "	249	58.8	41.2	30.3	10.9	7.4	2.9	0.6
" " Maximum of 7 specimens		58.8	55.6	39.5	18.6	10.5	7.3	0.8
" " Minimum " "		44.4	41.2	30.3	10.9	7.4	2.9	0.6
" " Average " "		50.1	49.9	35.2	14.7	9.2	4.8	0.7
Smelt, whole	23	34.8	65.2	52.3	12.9	10.4	1.2	1.3
" "	207	49.0	51.0	39.9	11.1	9.6	0.8	0.7
" " Average of 2 specimens		41.9	58.1	46.1	12.0	10.0	1.0	1.0
White fish, whole	18	53.5	46.5	32.5	14.0	10.3	3.0	0.7
Cisco, whole	111	42.7	57.3	43.6	13.7	11.0	2.0	0.7
California salmon, sections of anterior part of body	27	0.0	100.0	62.7	37.3	17.0	19.2	1.1
" " " " " "	233	10.3	89.7	57.9	31.8	16.1	14.8	0.9
" " " " " " Av. of 2 specimens		5.2	94.8	60.3	34.5	16.5	17.0	1.0
Salmon, female, whole	77	33.5	66.5	42.2	24.3	13.3	10.0	1.0
" " "	78	30.8	69.2	45.0	24.2	13.9	9.3	1.0
" " "	279	37.5	62.5	38.3	24.2	15.2	8.1	0.9

TABLE X.—*Continued.*

NAMES OF FISH AND PORTIONS ANALYSED.	Laboratory Numbers of Specimens.	Refuse: Entrails, Bones, Skin, etc.	Edible Portion. Flesh.	EDIBLE PORTION.				
				Water.	Water-free Substance. (Nutrients.)	Nutrients.		
						Albuminoids (by difference).	Fats.	Mineral Matters.
		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Salmon, male, whole	280	39.5	60.5	36.9	23.6	14.8	7.9	0.9
" whole. Maximum of 4 specimens		39.5	69.2	45.0	24.3	15.2	10.0	1.0
" " Minimum " "		30.8	60.2	36.9	23.6	13.3	7.9	0.9
" " Average " "		35.3	64.7	40.6	24.1	14.3	8.8	1.0
" entrails removed	14	23.8	76.2	51.2	25.0	14.6	9.5	0.9
Lake trout, "Mackinaw trout," whole	17	56.3	43.7	30.0	13.7	7.7	5.4	0.6
" " " entrails removed	255	35.2	64.8	45.0	19.8	12.4	6.6	0.8
Brook trout, whole, cultivated.	24	50.1	49.9	38.7	11.2	9.2	1.3	0.7
" " "	254	45.2	54.8	43.8	11.0	10.1	0.4	0.5
" "	256	49.1	50.9	38.6	12.3	10.2	1.5	0.6
" " Average of 3 specimens.		48.1	51.9	40.4	11.5	9.8	1.1	0.6
Pickerel, whole	100	45.4	54.6	43.6	11.0	10.0	0.3	0.7
" "	224	48.7	51.3	40.8	10.5	9.7	0.2	0.6
" " Average of 2 specimens		47.1	52.9	42.2	10.7	9.8	0.2	0.7
Pike (pickerel), whole	98	42.7	57.3	45.7	11.6	10.7	0.3	0.6
Mascalonge, whole	45	49.2	50.8	38.7	12.1	10.0	1.3	0.8
Eel, salt-water, skin, head and entrails removed	4	21.4	78.6	54.9	23.7	14.9	8.1	0.7
" " " " " "	217	19.0	81.0	59.4	21.6	14.3	6.4	0.9
" " " " " " Av. of 2 specimens		20.2	79.8	57.2	22.6	14.6	7.2	0.8
Mullet, whole	126	57.9	42.1	31.5	10.6	8.1	2.0	0.5
Mackerel, whole	8	38.3	61.7	48.5	13.2	11.2	1.4	0.6
" "	13	51.8	48.2	35.8	12.4	8.4	3.4	0.6
" "	30	48.9	51.1	37.9	13.2	8.9	3.6	0.7
" "	39	33.8	66.2	42.4	23.8	12.1	10.7	1.0
" "	261	50.4	49.6	37.4	12.2	9.5	2.1	0.6
" Maximum of 5 specimens		57.9	66.2	48.5	23.8	12.1	10.7	1.0
" Minimum " "		33.8	48.2	35.8	12.2	8.4	1.4	0.6
" Average " "		44.6	55.4	40.4	15.0	10.0	4.3	0.7
" entrails removed	230	40.7	59.3	43.7	15.6	11.4	3.5	0.7
Spanish mackerel, whole	43	34.6	65.4	44.5	20.9	13.7	6.2	1.0

TABLE X.—*Continued.*

NAMES OF FISH AND PORTIONS ANALYSED.	Laboratory Numbers of Specimens.	Refuse: Entrails, Bones, Skin, etc.	Edible Portion. Flesh.	EDIBLE PORTION.				
				Water.	Water-free Substance. (Nutrients.)	Nutrients.		
						Albuminoids (by difference).	Fats.	Mineral Matters.
		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Pompano, whole	234	42.4	57.6	38.8	18.8	10.5	7.8	0.5
" "	263	48.6	51.4	40.2	11.2	9.9	0.8	0.5
" " Average of 2 specimens		45.5	54.5	39.5	15.0	10.2	4.3	0.5
Blue fish, entrails removed	12	48.6	51.4	40.3	11.1	9.8	0.6	0.7
Butter fish, whole	90	42.8	57.2	40.1	17.1	10.2	6.3	0.6
Black bass (large-mouthed), whole	53	56.0	44.0	34.6	9.4	8.5	0.4	0.5
" " (small-mouthed), "	91	53.6	46.4	34.7	11.7	10.0	1.1	0.6
Yellow perch, whole	127	62.7	37.3	30.0	7.3	6.7	0 2	0.4
" " head, entrails, fins and tail removed	208	35.1	64.9	50.7	14.2	12.6	0.7	0.9
Wall-eyed pike, whole	52	57.2	42.8	34.1	8.7	7.9	0.2	0.6
Gray pike, whole	257	63.2	36.8	29.7	7.1	6.4	0.3	0.4
Striped bass, whole	7	56.7	43.3	34.2	9.1	7.9	0.7	0.5
" " "	19	56.9	43.1	34.4	8.7	7.2	0.9	0.6
" " "	225	48.6	51.4	39.7	11.7	9.7	1.4	0.6
" " "	237	57.1	42.9	32.5	10.4	8.3	1.6	0.5
" " "	248	55.4	44.6	34.7	9.9	8.4	1.0	0.5
" " "		57.1	51.4	39.7	11.7	9.7	1.6	0.6
" " " Maximum of 5 specimens		48.6	42.9	32.5	8.7	7.2	0.7	0.5
" " " Minimum " "		54.9	45.1	35.1	10.0	8.3	1.1	0.6
" " " Average " "		51.2	48.8	37.4	11.4	8.7	2.2	0.5
" " entrails removed	260	63.2	36.8	27.8	9.0	6.5	2.1	0.4
White perch, whole	44	61.8	38.2	28.9	9.3	7.8	1.0	0.5
" " "	46	62.5	37.5	28.4	9.1	7.2	1.5	0.4
" " " Average of 2 specimens		56.1	43.9	34.8	9.1	8.3	0.2	0.6
Sea bass, whole	251	55.8	44.2	35.3	8.9	8.2	0.2	0.5
Red grouper, entrails removed	114	55.9	44.1	34.8	9.3	8.5	0.3	0.5
" " " "	271	55.9	44.1	35.0	9.1	8.4	0.2	0.5
" " " " Average of 2 specimens		40.0	60.0	46.9	13.1	12.0	0.4	0.8
Red snapper, whole	20	52.5	47.5	36.8	10.7	9.2	0.9	0.6
" " entrails removed	26	45.3	54.7	43.7	11.0	10.0	0.3	0.7
" " entrails and gills removed	242	48.9	51.1	40.3	10.8	9.6	0.6	0.6
" " dressed. Average of 2 specimens								

TABLE X.—*Continued.*

NAMES OF FISH AND PORTIONS ANALYSED.	Laboratory Numbers of Specimens.	Refuse: Entrails, Bones, Skin, etc.	Edible Portion. Flesh.	EDIBLE PORTION.				
				Water.	Water-free Substance. (Nutrients.)	Nutrients.		
						Albuminoids (by difference).	Fats.	Mineral Matters.
		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Porgy, whole	15	65.1	34.9	27.8	7.1	6.1	0.5	0.5
" "	31	57.3	42.7	30.7	12.0	8.0	3.4	0.6
" "	262	57.6	42.4	31.1	11.3	8.2	2.5	0.6
" " Maximum of 3 specimens		65.1	42.7	31.1	12.0	8.2	3.4	0.6
" " Minimum " "		57.3	34.9	27.8	7.1	6.1	0.5	0.5
" " Average " "		60.0	40.0	29.9	10.1	7.4	2.1	0.6
Sheepshead, entrails removed	48	56.5	43.5	31.3	12.2	8.8	2.9	0.5
" whole	250	66.0	34.0	26.9	7.1	6.4	0.2	0.5
Red bass, whole	270	63.5	36.5	29.8	6.7	6.1	0.2	0.4
King fish, "	252	56.6	43.4	34.4	9.0	8.1	0.4	0.5
Weak fish, "	273	51.9	48.1	38.0	10.1	8.4	1.1	0.6
Black fish, "	38	56.2	43.8	33.7	10.1	8.3	1.2	0.6
" " "	205	64.1	35.9	29.2	6.7	6.3	0.2	0.2
" " entrails removed	244	57.8	42.2	33.5	8.7	7.9	0.4	0.4
" " " "	269	53.6	46.4	36.4	10.0	8.7	0.7	0.6
" " whole. Average of 2 specimens		60.1	39.9	31.5	8.4	7.3	0.7	0.4
" " dressed. " " "		55.7	44.3	35.0	9.3	8.3	0.5	0.5
Hake, entrails removed	113	52.5	47.5	39.5	8.0	7.2	0.3	0.5
Cusk, " "	110	40.3	59.7	49.0	10.7	10.1	0.1	0.5
Haddock, entrails removed	16	51.4	48.6	39.0	9.6	8.9	0.1	0.6
" " "	21	51.6	48.4	39.7	8.7	7.8	0.1	0.8
" " "	229	48.0	52.0	42.9	9.1	8.3	0.2	0.6
" " "	259	52.9	47.1	38.5	8.6	7.9	0.2	0.5
" " " Maximum of 4 specimens		52.9	52.0	42.9	9.6	8.9	0.2	0.8
" " " Minimum " "		48.0	47.1	38.5	8.6	7.8	0.1	0.5
" " " Average " "		51.0	49.0	40.0	9.0	8.2	0.2	0.6
Cod, head and entrails removed	3	33.7	66.3	55.3	11.0	9.9	0.2	0.9
" " " "	11	30.6	69.4	57.9	11.5	10.4	0.3	0.8
" " " "	228	25.5	74.5	62.1	12.4	11.4	0.2	0.8
" whole	206	56.5	43.5	35.1	8.4	7.7	0.1	0.6
" "	243	48.5	51.5	42.3	9.2	8.3	0.3	0.6

TABLE X.—*Continued.*

Names of Fish and Portions Analysed.	Laboratory Numbers of Specimens.	Refuse: Entrails, Bones, Skin, etc.	Edible Portion. Flesh.	Edible Portion.			
				Water.	Water-free Substance (Nutrients.)	Nutrients.	
						Albuminoids (by difference).	Fats.	Mineral Matters.
		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Cod, dressed. Average of 3 specimens		29.9	70.1	58.5	11.6	10.6	0.2	0.8
" whole. " 2 "		52.5	47.5	38.7	8.8	8.0	0.2	0.6
Tom-cod, whole	99	59.9	40.1	32.7	7.4	6.8	0.2	0.4
Pollock, head and entrails removed	81	28.5	71.5	54.3	17.2	15.5	0.6	1.1
Halibut, posterior part of body, lean	1	23.1	76.9	60.9	16.0	13.4	1.7	0.9
" section of body, fatter than No. 1	9	11.2	88.8	62.3	26.5	16.1	9.4	1.0
" sections from different parts of body	211	18.7	81.3	62.6	18.7	15.8	2.2	0.7
" average of 3 specimens		17.7	82.3	61.9	20.4	15.1	4.4	0.9
Turbot, whole	49	47.7	52.3	37.3	15.0	6.8	7.5	0.7
Common flounder, entrails removed	2	57.0	43.0	35.8	7.2	6.3	0.3	0.6
" " whole	22	66.8	33.2	27.2	6.0	5.2	0.3	0.5
Winter flounder, whole	253	56.2	43.8	37.0	6.8	6.1	0.2	0.5
Lamprey eel, whole	236	45.8	54.2	38.5	15.7	8.1	7.2	0.4
Skate, left lobe of body	247	51.0	49.0	40.2	8.8	7.5	0.7	0.6
SPENT FISH.								
Salmon, male, whole	35	43.8	56.2	42.3	13.9	10.8	2.5	0.6
" female, whole	36	43.5	56.5	44.2	12.3	10.0	1.6	0.7
" whole. Average of 2 specimens		43.6	56.4	43.3	13.1	10.4	2.1	0.6
" land-locked, male, whole	40	48.4	51.6	40.2	11.4	8.7	2.1	0.6
" " female, whole	41	46.2	53.8	42.6	11.2	9.5	1.0	0.7
" " whole. Average of 2 specimens		47.3	52.7	41.4	11.3	9.1	1.6	0.6
ROE.								
Shad roe, from shad No. 245	246	0.0	100.0	71.2	28.8	23.4	3.8	1.6
PRESERVED FISH.	Salt.							
DRIED.	per ct.							
Desiccated cod, flesh desiccated and ground	2.9	79	0.0	97.1	15.2	81.9	74.6	1.9	5.4

TABLE X.—*Concluded.*

Names of Fish and Portions Analysed.	Salt.	Laboratory Numbers of Specimens.	Refuse: Entrails, Bones, Skin, etc.	Edible Portion. Flesh.	Edible Portion.			
					Water.	Water-free Substance. (Nutrients.)	Nutrients.	
							Albuminoids (by difference).	Fats.	Mineral Matters.
SALTED.	per cent.		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Mackerel, "No. 1 mackerel."	7.1	42	33.3	66.7	28.1	31.5	14.7	15.1	1.7
SALTED AND DRIED.									
Salt cod, "Channel fish."	17.3	34	25.5	57.2	40.0	17.2	15.7	0.3	1.2
" "Boat fish."	17.2	37	24.3	58.5	40.5	18.0	16.4	0.4	1.2
" Average of 2 specimens	17.2		24.9	57.9	40.3	17.6	16.0	0.4	1.2
" "Boneless cod fish."	19.1	25	0.0	80.9	54.4	26.5	22.1	0.3	4.1
Desiccated cod, flesh desiccated and ground	6.6	80	0.0	93.4	11.7	81.7	71.6	4.9	5.2
SALTED, SMOKED AND DRIED.									
Smoked herring	6.5	33	44.4	49.1	19.2	29.9	20.2	8.8	0.9
" haddock	1.4	88	32.2	66.4	49.2	17.2	16.1	0.1	1.0
" halibut	12.0	28	8.0	80.0	47.0	33.0	16.7	14.4	1.9
" "	12.1	218	5.9	82.0	44.9	37.1	21.6	13.6	1.9
" " Average of 2 specimens	12.1		6.9	81.0	46.0	35.0	19.1	14.0	1.9
CANNED.									
Sardines	0.0	87	5.0	95.0	53.6	41.4	24.0	12.1	5.3
Salmon	0.4	29	11.7	87.9	58.2	29.7	18.8	9.8	1.1
"	2.2	96	0.0	97.8	62.2	35.6	19.7	14.6	1.3
"	0.4	241	0.0	99.6	57.6	42.0	19.2	21.5	1.3
" Average of 3 specimens	1.0		3.9	95.1	59.3	35.8	19.3	15.3	1.2
Mackerel	1.9	94	0.0	98.1	68.2	29.9	19.9	8.7	1.3
Salt mackerel, "No. 2 mackerel."	7.9	95	17.0	75.1	35.8	39.3	14.0	23.2	2.1
" " " "	8.7	219	22.4	68.9	33.8	35.1	13.7	19.3	2.1
" " " " Average of 2 specimens	8.3		19.7	72.0	34.8	37.2	13.8	21.3	2.1
Tunny, "Horse mackerel."	0.0	240	0.0	100.0	72.7	27.3	21.5	4.1	1.7
Smoked haddock	5.6	275	0.0	94.4	68.7	25.7	21.8	2.3	1.6

ON THE DETERMINATION OF THE ATOMIC WEIGHT OF OXYGEN.

By Edward W. Morley.

To determine the atomic weight of oxygen from the specific gravities of oxygen and hydrogen, it is necessary to know the ratio of the volumes in which they combine. Gay Lussac found this ratio to be very nearly 2 : in computations of atomic weights it has usually been assumed that it is *exactly* 2. This assumption was of course justified until we should have a better determination of the ratio. In an interesting and important paper recently read before the Royal Society at London, Scott has made it very probable that the ratio is sensibly less than 2, and made it probable that it is less by some such quantity as .005. The importance of the subject, shown by the fact that several chemists in this country and in Europe are reported to be engaged in a determination of the atomic weight of oxygen, leads me to offer some comments on the paper of Scott, from which I cannot separate some description of processes with which I am myself occupied.

In Scott's experiments, the mixture of oxygen and hydrogen was found to contain from a two hundredth to a three thousandth of its volume of nitrogen, perhaps mixed with carbon dioxide. By ingenious reasoning he deduces the conclusion that the ratio sought cannot be greater than 1.994. Unless it be determined how much of this nitrogen came from the hydrogen and how much from the oxygen, it is possible only to determine a maximum and minimum value for this ratio. The uncertainty will depend on the amount of impurity in the gases used in the experiment, and the uncertainty in the atomic weight of oxygen will be greater than the uncertainty in this ratio; for unless Regnault was much more successful than Scott in preparing pure gases, the specific gravity of the gases according to his determinations will be as uncertain as the ratio of combining volumes, so that the uncertainty in the product of the two ratios will be doubled.

I have been occupied for some time with the redetermination of the atomic weight of oxygen. One of the methods which I am preparing to use consists in weighing a sample of oxygen and one of hydrogen at a given pressure, determining the amount of

impurity in each gas, and determining the ratio of the combining volumes of the gases at the same pressure. Then a simple correction for the amount of impurity in each gas will give the ratio of specific gravities and combining volumes for the *pure* gases. The method involves the following operations:

1. A counterpoised globe *a*, a smaller globe *b*, a baromanometer, and a Sprengel pump are fused to a tube leading to an air pump. They also connect with a mercurial stopcock leading to a hydrogen generator. By the air pump, a high exhaustion is produced in the system. When the globes are exhausted and dried, dry hydrogen is admitted to the system; this hydrogen will be at about the atmospheric pressure while passing through drying tubes, and will be expanded only on passing the mercurial stopcock, so that the drying tubes will not be rendered ineffective. The hydrogen will not pass through one globe to reach the other, but will pass simultaneously from the connecting tube to the two globes, so that both will contain samples of identical composition.

2. The globe *a* being at 0° C., the manometer will be read, and the globe fused off and weighed, while *b* will be still connected with the Sprengel pump and the manometer.

3. The globe *a* is connected with a second manometer and Sprengel pump, and with a third globe *c*, as before, also with an air pump and oxygen generator. The system is filled with oxygen, and the globe *a* is then fused off and weighed.

4. *b* and *c* now contain samples of oxygen and hydrogen identical with those weighed, capable of preservation for any length of time, and capable of transfer by the Sprengel pumps without the least admixture. A quantity of oxygen is taken from *c* and measured at the pressure at which the sample in *a* was measured for weighing; two similar quantities of hydrogen are taken from *b*, these are mixed and exploded, the residue determined, exploded with oxygen or hydrogen as may be necessary, and the residual nitrogen determined.

5. Hydrogen is taken from *b*, but instead of passing at once to the eudiometer, it is passed through a tube containing heated copper oxide in a high vacuum. After passing into it, say, 200 cc. of hydrogen, the tube is cooled, and 200 cc. are passed in the cold and the tube exhausted till the whole gas passed into it has been carried out. By the manometer, the amount of gas passed in is measured; by the eudiometer, the gas remaining is measured;

so that the contraction by reduction of the copper oxide is known, and hence the difference between the percentage of impurity in the entering and outgoing gas is known. This hydrogen is mixed with a measured quantity of oxygen from *c*, exploded, and the residual nitrogen determined as before. For ease of explanation, suppose that in 4 the quantities involved were all known, and were as follows: hydrogen 200, containing 199 hydrogen and 1 nitrogen; oxygen 100, containing 99 oxygen and 1 nitrogen; after explosion, 2 nitrogen.

In the present operation the impurity in the hydrogen would be doubled, so that we should have: hydrogen 200, containing 198 hydrogen and 2 nitrogen; oxygen 100, containing 99 oxygen and 1 nitrogen; after explosion, 3 nitrogen.

It is obvious that the difference between the nitrogen found in 4 and in 5 is the nitrogen contained in the 200 cc. hydrogen which were consumed by passing over copper oxide.

6. In a similar way, oxygen from *c* is passed over heated copper so as to reduce 200 cc. to 100 cc., and this oxygen is exploded with hydrogen from *b*. We thus measure directly the nitrogen contained in the oxygen of *c*. The determinations of nitrogen from oxygen and from hydrogen check each other, for the sum must equal the nitrogen found in the first experiment.

We now have the data for correcting the weights of the oxygen and hydrogen weighed in *a* for the impurity contained in them, and also for correcting the results of the explosions, so as to get the ratio of combining volumes of *pure* hydrogen and oxygen. The accuracy to be expected depends on the accuracy of eudiometric measurements and of weighings. With the apparatus which I use for the experiments it is easy to reach an accuracy of one part in 25,000, and practicable to double this accuracy. As three determinations, each involving six measurements, are involved in the process, the average error to be expected in the process is one part in 10,000. Now, with a balance carrying 1200 grams in each pan, it is possible to weigh only about one gram of hydrogen. To determine this within less than half a milligram is very difficult. Even if the globe be sealed by fusion, so that weighings can be repeated for a long time, it would not be possible to depend on the weight of the hydrogen to one part in 10,000. In a second series of experiments, therefore, I intend to weigh a much larger volume of hydrogen or oxygen. In these experiments a globe as large as

can be made will be connected with a manometer and a mercurial stopcock, and exhausted. A weighed generator, giving pure dry hydrogen, will be connected to it by a special joint, the sealed delivery tube of the generator be broken off, and gas passed into the globe. Then the generator is sealed off and weighed, the globe is surrounded with melting ice, and the volume of the gas measured. In this case the tubes connecting the globe with the manometer are filled with gas, not at o°C., but at some other temperature. The volume so filled, however, may be made small, and the resulting error may be made very small by measuring oxygen and hydrogen in the apparatus under identical circumstances. If in this way it be possible to obtain five grams of hydrogen from an apparatus weighing not more than 1200 or 1500 grams, we can perhaps reduce the error in determining the ratio of the two specific gravities to a third or fifth of the error when a smaller volume is used.

With this large balloon it is necessary to store up a part of the gas first measured in it to be exploded with the gas measured second. This involves its transfer to another vessel; but by exhausting this other vessel, admitting some of the gas, and exhausting again, the difference between the composition of the gas as measured and as stored in the other vessel may be made as small as is required. The process for determining the residual impurity in each gas, and the ratio of combining volumes, is the same in this case as in the last.

It is hoped that individual results obtained by these methods will agree closely with each other and with the truth; but the truth must be learned from the coincidence of the results of several methods. Now it is well known that there are sources of constant error in the syntheses of water hitherto made by passing hydrogen over heated copper oxide; I therefore expect to repeat this synthesis with the improvements suggested by the advance of our knowledge during the last forty years. For instance, the apparent weight of the oxygen used in the synthesis is diminished by the amount of hydrogen absorbed by the reduced copper, and by the amount of oxygen mixed with the current of hydrogen. The first error can be measured and a correction applied; the second can be avoided. It is also easy to devise apparatus which shall permit the weighing of the tube with copper oxide, and the tube for collecting water, deliberately, repeatedly, after any desired interval,

and with great accuracy. My experiments on the amount of moisture left in a gas after drying with sulphuric acid or phosphorus pentoxide were, in part, a study of the means of weighing similar apparatus much more accurately than is usual.

It is very likely that the constant errors just mentioned are very small, but the best assurance of this fact would be found in the agreement of results by this method with those by other methods, if such could be devised. Accordingly I shall make a synthesis of water from a weighed quantity of hydrogen. In one series of experiments, a generator with its drying tube will be sealed and weighed when freed from oxygen and nitrogen. It will then be connected by a leakage-proof joint with an apparatus where, after its fused point shall be broken off, a current of hydrogen will be mixed with dry oxygen in excess, and passed over heated platinum sponge and resulting water collected and weighed. The generator will again be sealed up and weighed.[1] The advantage of this process is mainly that it is *another* process, and that therefore the sources of constant and of accidental error in it will be different from those in the process with a weighed quantity of oxygen. It is well to note that there is no important advantage in determining the hydrogen directly. In the older process the water is determined by the difference of two weighings, the oxygen is determined by the difference of two other weighings, and the hydrogen by the difference of these differences. In the present process the hydrogen is determined by the difference of two weighings, the water by the difference of two, and the oxygen by the difference of the differences. Now, the weight of the hydrogen, however obtained, is a small number, and a slight absolute error is a large error relatively to this small number; and this is equally true in both processes. The advantage of the new process is that the hydrogen is determined by two weighings instead of four, so that the error in its weight would in a large number of experiments be 30 per cent. less, if all the weighings were of something like similar amounts and capable of the same accuracy, which is a nearly correct supposition.

If the method just mentioned gives valuable results, I shall probably use another method which suggested itself before the last. It consists in weighing the hydrogen after first having it absorbed

[1] Keiser has made a similar synthesis by passing hydrogen over heated copper oxide. Is it possible in this way to burn completely a quantity of hydrogen?

by finely divided palladium, and sealing it in a flask. After breaking off the sealed point, the gas will be extracted by a Sprengel pump, aided by the use of heat, the gas will be mixed with a current of oxygen, and the resulting water collected and weighed.[1]

I have been devising the apparatus required for these determinations for more than three years. Owing to ill health, the only parts of the plan yet completed are the preliminary determination of the completeness of drying possible with sulphuric acid and phosphorus pentoxide. The vast amount of work required in devising and proving apparatus so complicated as that in hand is well known to those engaged in similar labors. This is now approaching completion; I hope for useful results at no very distant day.

CLEVELAND, OHIO, *November* 29, 1887.

INVESTIGATIONS ON THE OXIDATION OF SEWAGE.

BY J. H. LONG.

Something over a year ago I began a series of experiments for the Illinois State Board of Health, intended to show the rate of oxidation or destruction of sewage in a canal flowing west from the city of Chicago, and discharging finally into the Illinois river.

The peculiar situation of Chicago and its system of drainage dependent on this make such tests unusually interesting, and I wish, in the following, to present some of the results obtained in the work.

Only a few miles south and west of the city is found the low watershed separating the basin of Lake Michigan from that of the Mississippi. On the Chicago side of this "divide" is the Chicago river, mostly within the city limits, which serves as a harbor for shipping, and likewise as a receptacle for the greater part of the sewage from a population of about 800,000.

Many years ago the Illinois and Michigan Canal was constructed, connecting Lake Michigan through the river with the

[1] The use of palladium for the synthesis of water independently suggested itself to Keiser. I described my method in conversation in October, 1884.

Illinois river at a point about 48 miles southwest of the city. This canal is supplied with water by pumps located at Bridgeport, within the city limits, five miles from the lake, which at present lift about 50,000 cubic feet per minute and discharge it toward the west.

The canal, then, at its eastern end, is fed by dilute sewage, and it is the changes in this that I have to explain.

This dilute sewage is made up chiefly of three elements:

1. Of the water of Lake Michigan. This water contains in parts per million 136 parts of total solids, and furnishes of free ammonia from 0 to .01 part per million, and of albuminoid ammonia .070 part per million. In oxidation by the Kubel process about one part per million of oxygen is required.

2. Of about 70,000,000 gallons per day of sewage proper. We have no accurate data showing the average composition of this as it leaves the sewers, but samples taken near the mouths of some of these showed large amounts of free ammonia, indicating an advanced stage of decomposition.

3. Of about 7,000,000 gallons daily of sewage from the large stockyards south of the city. The character of this has been investigated. In samples analysed last autumn I found the solid matter to amount to about 9200 parts per million, with between 3000 and 4000 parts of organic matter. Samples were taken every hour through the twenty-four, mixed and analysed, after dilution with pure water. In this way I found for one day, October 29th, in parts per million:

Free ammonia, ...	42
Albuminoid ammonia, ...	6.4
Oxygen consumed, ...	208

The results obtained on other days averaged about the same.

Collection and Analysis of Samples.

The waters were taken in gallon jugs on the same day at the several stations, and sent to me by express. They were examined as soon as possible after their receipt.

After necessary dilution with pure water I determined free and albuminoid ammonia, taking precautions to make these experiments as accurate and uniform as practicable. I also found the consumption of oxygen by the Kubel process. Full details of the

several methods, as followed, were given in my reports to the State Board of Health last winter, which, however, are not yet published.

The Water at Bridgeport.

Ten analyses were made of the water just as it reached the pumps. The first tests were made on water taken on June 26th, 1886, and the last on water taken on August 28th, with results as follows:

	In 1,000,000 Parts.		
	Free Ammonia.	Alb. Ammonia.	Oxygen consumed.
June 26	2.6	.64	12.0
July 3	2.7	.52	6.8
10	4.2	.62	16.8
17	25.0	1.50	22.4
24	5.5	.37	12.6
31	23.0	1.76	23.2
Aug. 7	26.0	1.50	16.8
14	29.0	1.64	32.0
21	27.2	1.50	28.0
28	29.2	1.90	35.2
Mean	17.44	1.195	20.58

The smaller amounts of contamination in the first tests can be accounted for by the fact of a high lake level, in consequence of which the sewage outflow from the stockyards' sewer and other sewers was at times much retarded and a comparatively clean water reached the pumps from the lake.

The Water at Lockport.

After leaving the pumps the water flows along the level to Lockport, 29 miles below, requiring about a day for its passage. The canal water receives no additions between the two places, that is, it is not diluted by any other stream or feeder. The rainfall during the summer of 1886 was unusually small, in fact, the lowest in 15 years. Dilution from this source can be left quite out of consideration, and owing to the frequent passage of propellers and other boats no very great change in the character of the water by sedimentation could take place.

The tests gave:

	In 1,000,000 Parts.		
	Free Ammonia.	Alb. Ammonia.	Oxygen consumed.
June 26	2.8	.56	11.36
July 3	2.4	.42	7.2
10	...	...	...
17	10.2	.72	12.8
24	9.2	.47	14.8
31	11.0	.72	10.7
Aug. 7	12.0	.48	9.6
14	15.2	.88	9.76
21	15.0	.84	10.8
28	13.0	.88	12.4
Sept. 4	11.5	.72	13.6
Mean	10.23	.669	11.30

The Water at Joliet.

After passing Lockport the water descends to Joliet through four locks, and falls over a dam seven feet in height, to point of collection. There is a fall of 58.2 feet in a distance of four miles, and no dilution takes place on the way.

The tests gave results as follows:

	In 1,000,000 Parts.		
	Free Ammonia.	Alb. Ammonia.	Oxygen consumed.
June 26	1.7	.46	7.36
July 3	1.8	.46	9.76
10	2.4	.56	9.20
17	13.0	.44	14.50
24	...	...	...
31	9.2	.44	5.68
Aug. 7	7.5	.42	5.84
14	9.8	.46	5.76
21	9.0	.112	.520
28	8.0	.32	6.80
Mean	6.93	.408	7.79

Although there are certain irregularities in the above table which cannot now be explained, a general decrease of organic matter is plainly shown; and it will also be noticed that the percentage of

loss per mile is much greater between Joliet and Lockport than between the latter and Bridgeport. This is undoubtedly due to the more perfect aeration of the water secured by the passage through the locks and over the dam.

The loss per mile is this, expressed in terms of amount at upper station:

	Free Am.	Alb. Am.	Oxygen used.
Bridgeport to Lockport,	1.44 per ct.	1.52 per ct.	1.55 per ct.
Lockport to Joliet,	8.06 per ct.	9.75 per ct.	7.76 per ct.

Thus the loss of free ammonia per mile between Bridgeport and Lockport is 1.44 per cent. of the amount at Bridgeport, while the loss between Lockport and Joliet is 8.06 per cent. of the amount at Lockport.

Through a good part of its course the canal flows parallel to the Des Plaines river, which, 48 miles below Bridgeport, unites with the Kankakee to form the Illinois, into which also a large portion of the canal water is diverted.

The next tests were made at Ottawa, 48 miles below Joliet and 73 feet lower. The Fox river joins the Illinois at this point, so that the canal water becomes very much diluted. From surveys and measurements made recently it has been estimated by Mr. L. E. Cooley, of the Chicago Drainage and Water Supply Commission, that at the period under investigation—the summer of 1886—43 per cent. of the water at this point came from the canal, and the rest from the streams named.

The chemical tests gave:

	In 1,000,000 Parts		
	Free Ammonia.	Alb. Ammonia.	Oxygen consumed.
June 26	.50	.23	7.05
July 3	.104	.21	.576
10	.22	.164	4.96
17	.56	.252	6.54
24	...	...	...
31	.49	.250	6.00
Aug. 7	.52	.32	6.40
14	.30	.144	4.80
21	...	...	...
28	.36	.33	3.12
Mean	.382	.237	5.57

These figures show a remarkable decrease in the free ammonia, the loss amounting to 94.5 per cent. of the quantity at Joliet. This is partly accounted for by the large dilution, as 57 per cent. of the water here comes from sources other than the canal, as explained; but, unfortunately, it is not possible to express numerically the effect of this dilution, as we do not know the exact composition of diluting waters.

At first sight it would appear that, taking into consideration the amount of dilution, instead of there being a loss of albuminoid ammonia and oxygen consumed there is a gain in this flow of 48 miles. This apparent anomaly can be explained, I think, without great difficulty.

The streams feeding the Illinois flow through a rich soil and partly swampy regions, where relatively large quantities of organic matter are taken up. The Sangamon river in this State is in some respects analogous to the Kankakee. I analysed a sample of its water taken at Decatur in the summer of 1885, and found it very highly contaminated with vegetable matter, partly suspended and partly in solution. The organic matter dissolved amounted to about 40 parts per 1,000,000, and other tests gave in parts per 1,000,000:

Free ammonia	.013
Alb. ammonia	.170

I have no doubt that the river water at Ottawa, free from sewage, would show as large an amount of nitrogenous matter as these figures indicate.

It must also be remembered that the sewage of several towns enters the river above Ottawa. Joliet, which is sewered pretty completely, has a population of 15,000, while the other sewered places may have 5000 more. It is fair, then, to believe that a moderate change in the amount of organic matter has occurred between the two stations. The probability of such change is shown by the determinations made at Peoria, 78 miles below Ottawa, but at a lower level of only 15.5 feet.

There are no tributaries of any consequence between these cities. The proportion of canal water is decreased only from 43 per cent. to 39 per cent., while sewage from several important towns is taken up.

It may also be added that the total flow at Peoria amounted to

about 125,000 cubic feet per minute at the time of the tests, while about 22 days were required for the descent from Ottawa.

The tests gave:

	In 1,000,000 Parts.		
	Free Ammonia.	Alb. Ammonia.	Oxygen consumed.
June 26	.036	.150	5.04
July 3	...	...	...
10	.084	.150	5.04
17	...	...	...
24	...	...	...
31	.0048	.196	4.64
Aug. 7	.0072	.210	6.80
14	.042	.190	4.72
21	.066	.212	4.88
28	.009	.206	2.80
Mean	.0355	.1877	4.85

Unfortunately, there are three breaks in this table, due to the neglect of the persons expected to forward the water. The tests carried out showed, as at Ottawa, a marked loss of free ammonia, which must be explained chiefly by oxidation. There is likewise a perceptible diminution in the amount of oxygen consumed and in the albuminoid ammonia, even after the dilution is taken into consideration.

It is plain that in this long stretch of 78 miles with a fall of only 15 feet the water must be in many places practically stagnant, and we know that under such circumstances oxidation of organic matter is necessarily slow. The conversion of ammonia into nitrates is apparently much more rapid. It is possibly true that the residual organic matter represented by the oxygen consumption and albuminoid ammonia is of a relatively stable type, capable of resisting complete change for a long period, but which may be broken up with comparative ease by the reagents of the laboratory processes. Many of the vegetable matters finding their way into these waters are of that nature, as numerous experiments have shown.

It must also be borne in mind, as mentioned above, that a certain amount of sewage is discharged into this portion of the river, and taking all these points into consideration, it is fair to conclude that destruction of organic matter is going on here at a moderate rate, but less rapidly than above.

It would be interesting to know the condition of affairs in the stream between Peoria and its junction with the Mississippi, a distance of some 200 miles. An investigation of this nature is contemplated for the near future.

The above tests show in a fair and unmistakable way the general fact of the gradual purification of a highly contaminated water by what may be broadly termed oxidation. In the upper part of the course sedimentation cannot be called into account for much of this change, as the water undergoes frequent agitation by passing boats. In the lower part of the course this disturbance is less frequent, but at the same time the matter which could be lost by sedimentation is less abundant.

I am therefore led to attach considerable importance to these investigations, as showing pretty fully the rate at which a city's sewage is destroyed under certain conditions of temperature, dilution, and velocity of flow. In most similar investigations these important data are given imperfectly or not at all, so that to draw a legitimate conclusion is almost impossible.

Oxidation in Winter.

It is generally admitted that destruction of sewage is less rapid in winter than in summer, although direct chemical experiments bearing on that point are very few.

During last winter the above investigations were continued so as to show as nearly as possible just what the effect of the cold really is. The waters were taken at the same places by the same observers and examined in the same way. The results of these examinations are given in the following table—the results expressed in parts per 1,000,000:

From.	When taken.	Free Ammonia.	Albuminoid Ammonia.	Oxygen consumed.
Bridgeport, . . .	Dec. 18,	17.60	4.80	28.8
	Jan. 18,	6.60	3.50	16.0
	29,	5.90	3.80	22.4
	Feb. 3,	10.60	3.70	32.8
Lockport, . . .	Dec. 6,	3.70	.56	17.6
	Jan. 3,	9.20	3.90	21.6
Joliet, ...	Dec. 7,	11.00	.60	16.8
	13,	13.00	1.80	19.2
	20,	13.20	3.30	21.6
	27,	18.40	4.90	24.8

From.	When taken.	Free Ammonia.	Albuminoid Ammonia.	Oxygen consumed.
Joliet, ...	Jan. 1,	11.60	3.72	19.6
	8,	8.40	4.20	18.4
	15,	5.40	3.00	10.0
	22,	3.24	1.76	14.4
	29,	3.20	1.54	10.0
	Feb. 4,	3.80	2.22	19.2
Ottawa, ...	Dec. 9,	1.52	.54	10.4
	13,	5.74	2.60	15.2
	22,	6.80	1.20	11.2
	28,	.96	2.92	*60.0
	Jan. 4,	8.20	2.70	10.8
	8,	2.20	2.80	*44.0
	22,	2.60	.30	6.8
	29,	.36	.32	†11.2
	Feb. 5,	3.70	.38	9.2
	12,	3.20	.46	10.8
Peoria, ...	Jan. 15,	1.26	.25	4.4
	22,	3.60	.68	7.36
	29,	.52	.36	7.60
	Feb. 2,	.90	.36	8.80
	7,	.72	.34	7.90

In the above table there are many perplexing irregularities, some of which can be explained, while for others the data are lacking.

On the 7th of December, owing to an accident, pumping was stopped at Bridgeport, and did not begin again until December 27th. During this time the flow under the ice through the canal amounted to about 15,000 cubic feet per minute by gravity, while the flow in the small rivers below was likewise lessened. After December 27th the pumps forced about 50,000 cubic feet per minute through the winter.

In January there is shown a decrease in the free ammonia with an increased amount of albuminoid ammonia and oxygen consumed at Bridgeport and Joliet, as compared with the summer rate, while at Ottawa and Peoria all these factors are increased. After the close of navigation sedimentation plays an important part in

*Very unusual color and odor.

† This sample was taken on January 29, but not forwarded until a week later.

the still water. For this reason purification appears more rapid than is actually the case.

Near the source of contamination we can understand that free ammonia is not so quickly formed, because of the low temperature; and for the same reason, when once formed, it is not so readily oxidised at points further down in the stream.

The effect of the stoppage of the pumps is shown in the albuminoid ammonia as late as January 8th at Ottawa. After this date, between Ottawa and Peoria there seems to be no change in the organic nitrogenous matter, the amount at the latter place being about twice as great as during the summer.

The waters collected at Peoria during the summer were without odor, while through the winter it was frequently quite marked. It is said to be very noticeable at holes broken in the ice, and if the filth left above by deposition reached here it would be much worse.

This state of the water can be partly accounted for by the diminished flow from some of the streams feeding the Illinois, but the chief factor is undoubtedly the low temperature. A coating of ice excludes the air, and thus prevents direct oxidation when this is possible. A more important result of lower temperature is found in the diminished activity of bacterial ferments. These are probably the chief agents in the decomposition of organic filth, and their efficiency is greatest at moderate temperatures.

The above experiments, while not as complete as could be desired, show several important points. Even under the unfavorable conditions in the canal and river, it is seen that sewage is pretty rapidly decomposed in summer. With a greater velocity of the flowing water this change would undoubtedly be much more complete.

The slow rate of winter change is clearly shown. These results suggest another very interesting inquiry, viz: At what rate is *rapidly moving* sewage oxidised in winter? An answer to this, with statement of all conditions, would have a great practical value.

CHICAGO, *August* 10, 1887.

NOTES OF WORK FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF VIRGINIA. No. XVI.

Communicated by F. P. DUNNINGTON.

134.—ON TITANIC OXIDE IN SOILS.

BY J. F. MCCALEB.

Through the analysis of what proved to be a fulgerite, which was described by me before the Chemical Section of the A. A. A. S. at its meeting of 1885,[1] titanic oxide was found to exist in certain soils of Albemarle Co., Va.

Attention has also been called, in a communication from this laboratory,[2] to the wide distribution of titanic oxide as menaccanite, and also as imparting color to the blue quartz which occurs so abundantly throughout the Piedmont region of Virginia. It was therefore proposed to Mr. McCaleb to examine for titanic acid the soils of this vicinity and some others of which specimens were in hand.

The method pursued was that brought forward by A. Weller.[3] The powdered soil was fused with sodium acid sulphate, exhausted with cold water, the filtrate brought to a measured volume and hydrogen dioxide added; the yellow color thus produced was compared with that similarly obtained from a standard solution of titanic oxide. With each specimen the undissolved residue was re-fused with sodium acid sulphate until either very little or no titanium was found in the filtrate.

Samples of soil were taken from nine points, situated approximately in three lines, all parallel to the Southwest Mountains, which are about twenty miles southeast of the Blue Ridge and parallel to it.

Nos. (1), (2) and (3) from the slope of the Southwest Mountains and about one mile apart, all deep red soil; (2) being from the location of the fulgerite.

[1] Proc. A. A. A. S. **34**, 132. [2] Chemical News **50**, 207.
[3] Berichte der deutsch. chem. Gesell. **15**, 2592.

Nos. (4), (5) and (6) from corresponding points near the bottom of the mountain and in a line one-half mile distant. (4), alluvial in the bottom; (5), white sandy soil beyond the bottom; (6), red diorite soil beyond the bottom.

Nos. (7), (8) and (9) from corresponding points on rising ground, in a line two miles further to the northwest. (7), white micaceous soil, on higher land—from a micaceous schist; (8), red diorite soil, near the laboratory of the University; (9), white sandy soil, on slope of Observatory Mountain.

To these were added: (10), red soil, from Red Hill, situated about ten miles southwest of the University and geologically in the same belt of country; (11), alluvial soil from swamp on Rappahannock River, Stafford Co., Va.; (12), "black canebrake soil," near Uniontown, Perry Co., Alabama; (13), "alkaline soil," Truckee Valley, Nevada.

After Mr. McCaleb had examined the foregoing specimens I found opportunity to collect the following, in which also I estimated the titanic oxide: (14), red soil, from the Miller School farm, twelve miles west of the University; (15), deep red soil, near large deposit of titanic oxide, six miles east of Lowesville, thirty-five miles southwest of the University; (16), "limestone soil" lying at the foot of a hill of gneiss rock, Worthington's Valley, twenty miles northwest of Baltimore, Md.

The percent. of titanic oxide found in each of these respectively is as follows:

(1), 2.73	(5), .33	(9), .77	(13), .57
(2), 5.42	(6), 2.73	(10), 1.86	(14), 1.51
(3), 1.45	(7), 1.14	(11), .88	(15), 1.87
(4), 1.73	(8), 2.86	(12), .78	(16), 1.17

No doubt the fact that titanic oxide has not been observed to occur so generally distributed in soils is due to the unsatisfactory nature of the tests by which it heretofore was to be detected, when present in small amounts; but now that this test of A. Weller so simplifies the operation, it is hoped that soils in many other portions of the country will be so examined.

135.—ANALYSIS OF TSCHEFFKINITE FROM NELSON COUNTY, VIRGINIA.

By R. C. Price.

This mineral was discovered on Hat Creek, about 4 miles east of Massie's Mills, Nelson Co., Va. As far as I can ascertain, but a single lump weighing over twenty pounds has been found, and this lying loose upon the ground, where it was improbable that it had been transported any distance. There is much rutile in this vicinity, and in the same belt of country, within 15 miles, allanite has been found at two points in considerable amounts, as was described in previous communications[1] from this laboratory.

The piece examined appears to have been broken from a vein-like deposit 5 cm. thick, with a brown crust on either side where contaminated with the adjacent rock, but showing little evidence of weathering on other surfaces. It is amorphous and dull black, on a surface of fracture, with a few thin seams presenting a vitreous lustre, which latter were excluded from the portion analysed. Streak, grey; hardness, nearly 6; specific gravity, 4.4; fuses before the blowpipe at 3, with much intumescence, to a black glass. Is not magnetic before or after heating. Decomposed slowly by hydrochloric acid with separation of silica.

With borax it affords a clear yellow-brown glass, and with salt of phosphorus, a milky bead with pale brownish pink color.

For analysis it was decomposed by fusion with sodium acid sulphate, digested in cold water, and the silica filtered off and refused. The titanium was then precipitated by boiling, weighed, refused and redetermined in the solution by the calorimetric method with hydrogen dioxide, and the small amount of iron in this precipitate was estimated after reduction by sulphurous acid, the sum of these closely agreeing with the previous weight of the crude titanic acid precipitate.

For the determination of ferrous oxide the mineral was decomposed by heating in a sealed tube with hydrochloric acid and then titrated with permanganate. The separation of cerium, lanthanum and didymium was obtained by the methods of Winkler and Gibbs. Most of the determinations were made in duplicate, giving the following result:

[1] Chemical News **30**, 141; This Journal **7**, 177.

		Oxygen Ratio.	
SiO_2	23.28	776	776
TiO_2	21.16	579	617
ZrO_2	2.29	38	
Ce_2O_3	11.89	108	396
Di_2O_3	15.38	136	
La_2O_3	4.96	46	
Fe_2O_3	5.63	106	
FeO	5.56	77	276
BeO	2.15	86	
CaO	5.48	97	
MgO	.64	16	
Na_2O	.32	5	
H_2O	1.90	106	
	100.64		

When considering the cerium earths as protoxides, tscheffkinite was classified by Dana[1] as a subsilicate with titanic oxide basic; the oxygen ratio for

$$SiO_2 : TiO_2 : R_2O_3 : RO = 5 : 4 : 2 : 4.$$

With these earths sesquioxide, the above must be rejected; and in order to consider the published analyses of tscheffkinite (1) and (4),[1] I have assumed the cerium earths to exist in the same proportions as have been found in the present specimen, which affords oxygen ratio for them as follows:

	SiO_2.	TiO_2.	R_2O_3.	RO.
(1), Ilmen,	77	55	44	25
(4), Coromandel,	77	64	44	24
Nelson County,	78	62	40	28

From the inspection of these figures it appears highly probable that the titanic oxide should be regarded as replacing silica. The composition of the Nelson County mineral approximates to

$$2(Ca, Be, Fe, Mg)O \,.\, (Ce, Di, La, Fe)_2O_3 \,.\, 5(Si, Ti)O_2,$$[2]

and the formula of each of the above will fairly correspond to a bisilicate of the amphibole group, with silicon replaced by titanium.

[1] System of Mineralogy, 5th ed., p. 388.

[2] Since writing the above I find in Tafel-Uebersicht der Mineralien, Groth assigns a similar formula to both tscheffkinite and keilhauite.

136.—OXIDATION OF SOLUTIONS OF SULPHUROUS ACID AND SULPHITES.

By I. A. Bachman.

In a former communication from this laboratory, No. 115,[1] it was shown by Mr. Reese that solutions of sulphites are more rapidly oxidised on exposure than is sulphurous acid.

In continuation of this subject, it was proposed to Mr. Bachman to examine the relative rates of oxidation of the sulphites of the alkalies.

Five solutions were prepared, one litre of each containing 10 grams of sulphurous oxide, and by addition of the requisite amounts of the solutions of the alkaline hydrates there were obtained the following: *A*, sodium sulphite; *B*, potassium sulphite; *C*, ammonium sulphite; *D*, ammonium acid sulphite; *E*, sulphurous acid.

One litre of each of these was put into a half-gallon green glass acid bottle. These were kept in a cupboard, but exposed to daylight, the stoppers left out, and to promote oxidation, twice daily (except Sundays) the stoppers were inserted and the contents vigorously shaken.

After making all these solutions, on the same day, 5 cc. of each was treated with hydrogen dioxide and ammonia, and the sulphuric acid then precipitated as barium sulphate; again, 5 cc. of each was titrated with iodine solution, and all subsequent estimations of sulphurous oxide also were made by Bunsen's method. Samples were drawn at stated intervals and estimations made, with the results which are tabulated below.

Grams of SO_2 found in 1000 cc. of solution:

	Na_2SO_3. A.	K_2SO_3. B.	$(NH_4)_2SO_3$. C.	NH_4SO_3. D.	H_2SO_3. E.
After 2 hours, estimated by $BaSO_4$, ...	9.75	9.80	9.76	9.40	...
After 3–4 hours, estimated by I, . . .	9.14	8.68	9.20	9.51	8.03
After 1 day, estimated by I, ...	8.05	7.86	7.88	9.25	8.28
After 1 week, estimated by I, ...	4.14	3.26	4.46	8.05	5.54
After 2 weeks, estimated by I, ...	.77	.37	1.31	6.71	3.25

[1] Chemical News **50**, 219.

	Na_2SO_3. A.	K_2SO_3. B.	$(NH_4)_2SO_3$. C.	NH_5SO_3. D.	H_2SO_3. E.
After 3 weeks, estimated by I, ...	tr.	tr.	tr.	5.11	1.88
After 3 weeks, SO_2 oxidised, ...	all.	all.	all.	2.73	.67
After 3 weeks, SO_2 volatilised, ...	none.	none.	none.	1.96	7.25

From which we may draw the following conclusions:

First. There is very little difference in the rate of oxidation of the sulphites of sodium, potassium, and ammonium.

Second. There is a marked advantage in employing an acid sulphite where it may be substituted for a solution of a sulphite or of sulphurous acid and is to be kept as a reagent or dispensed as a medicine.

It may be added that this presents an illustration of the fact that the solution of an acid salt is not a mere mixture of neutral salt with free acid in solution.

137.—ANALYSIS OF VARVACITE FROM WYTHE CO., VIRGINIA.

By P. H. Walker.

This mineral was received from Mr. J. C. Raper, being found on his land near the lead and zinc mines of Austinville, Wythe County, Va.

It occurs imbedded in psilomelane and ferruginous clay, is in radiating fine fibrous crystals, the layers being 10 to 20 mm. in thickness. Color and streak brownish black. Hardness 1.5, soiling the fingers. Fuses at about 4, imparting streaks of green to the flame. Specific gravity 3.27. Analysis gave:

		Atomic Ratios.	
MnO_2	68.86	791	8
MnO	7.51	105	1
BaO	14.42	94	1
H_2O	5.08	282	3
SiO_2	1.98		
Fe_2O_3 and Al_2O_3	2.23		
	100.08		

It is of interest to note the large amount of barium in a specimen so well crystallised. The composition, excepting the barium, accords with that of varvacite, which is regarded by Dana[1] as an impure pyroluscite or manganite. The analysis also suggests lepidophacite,[2] for which Jenkins assigns the formula $CuMn_6O_{12} + 9H_2O$. In this view the above figures correspond to $BaMn_9O_{18} + 3H_2O$.

138.—ATTEMPT TO FORM ARSENIC NITRIDE.

By I. A. Bachman.

In view of the similarities of arsenious and boracic oxide, of the stability of boron nitride, and also of the recent production of arsenic phosphide,[3] the production of arsenic nitride was undertaken.

In the following account of the various experiments no record is made of the trials which proved unsatisfactory either by reason of too little heat or of explosions, of which there were many, some giving a loud report. To secure safety in opening the sealed tubes, care was taken to draw off one end to a fine bore, and when this was pinched off the pressure was relieved gradually.

Dry ammonia was passed over gently heated arsenious oxide; this resulted in condensation, in the cooler portion of the tube, of arsenic, arsenious oxide, and water only.

Into a combustion tube was introduced successively a mixture of ammonium sulphate and magnesia, asbestos plug, arsenious oxide, the air displaced by dry hydrogen, and the tube sealed. This was heated within an iron tube for one hour to about 300° C. On opening it (by cracking it lengthwise with a small flame) there was found, in separate deposits, arsenic, arsenious oxide, and at the least heated end of the tube arsenious sulphide.

To avoid the formation of a sulphide a tube was then charged with ammonium carbonate, lime, and arsenious oxide, separated by asbestos, the air displaced by hydrogen, and the tube sealed. This was heated for two hours to, probably, 350° C. at its hottest portion. After cooling, the tube was opened; it contained gases under great pressure and a heavy deposit of arsenic, most of the arsenious

[1] System of Mineralogy, 5th ed., pp. 166, 182.
[2] System of Mineralogy, 5th ed., Appendix III, p. 130.
[3] Berichte der deutsch. chem. Gesell. 6, 216.

oxide having been reduced, but no indication of any combination with nitrogen was presented.

Another series of experiments was then made, aiming to effect combination between the elements of cyanogen and arsenious oxide. A tube was charged with silver cyanide, asbestos, lime, asbestos, arsenious oxide, leaving half of the tube empty, and then sealed. It was heated rather hotter than before, probably 400° C., for two hours, and after cooling was opened. The lime had been largely converted to carbonate. The portion of the tube in which the arsenious oxide had been put was heated hottest and was found empty; above it was deposited in order arsenic, "brownish arsenious oxide," white arsenious oxide, and at the far end of the tube a moderate amount of a chocolate-brown deposit. The latter was found to afford ammonia on being heated in a tube with soda-lime, and to consist essentially of arsenious oxide.

It was then attempted to separate the portion containing nitrogen by gentle heat in a current of dry nitrogen, but this merely resulted in volatilising the whole, with a condensation of only arsenious oxide and arsenic.

In other tubes similarly charged it was noted that if any moisture was left in the tube ammonia was formed, and none of this brown substance.

It was then found best to charge the tube with silver cyanide, asbestos and arsenious oxide, heat just a little short of volatilising the arsenic, and then, on opening the tube, the arsenious oxide was altered to a loosely coherent chocolate-brown (in some cases almost black) substance, with the following properties: Heated in a closed tube, at first arsenious oxide volatilises, the mass becoming darker, melting, and then subliming to form a ring of arsenic, together with a thin brown deposit and arsenious oxide, insoluble in alcohol, ether, chloroform, carbon disulphide. Water dissolves it more rapidly than dilute acids do; dilute hydrochloric acid attacks it slowly; strong boiling hydrochloric acid or nitric acid turns it lighter in color and gradually dissolves it. Strong hot sulphuric acid completely dissolves it to form a yellow liquid, which on further heating loses this color; caustic soda solution does not completely dissolve it on boiling; fused caustic soda does dissolve it with decomposition. By aid of the microscope it appeared that the brown substance was a coating over the arsenious oxide crystals.

Ignited by Ruffle's method, it afforded of nitrogen, by titration, 1.8 per cent.; by nesslerising, 2.1 per cent. An estimation of the arsenic gave 76.61 per cent.; no satisfactory determination of the oxygen was made. It was thought possible that some paracyanogen might be present, but this brown material does not soil the fingers at all, and on combustion in a current of air affords only a minute amount of carbon dioxide. It appears, therefore, highly probable that this body contains arsenic nitride, but no method of removing the excess of arsenious oxide was discovered, and the approach of the close of the session prevented a continuation of the work.

139.—ANALYSIS OF "GENTHITE" FROM NORTH CAROLINA.

By P. H. Walker.

An analysis of this mineral, from Webster, Jackson Co., N. C., was made in this laboratory some time ago, and published;[1] but since but very little of the material was then available and the analysis not very satisfactory, it was of interest to repeat the work. Through the kindness of Dr. Memminger, of Charleston, some of this mineral was recently obtained. It occurs in layers of 1 to 3 mm. in thickness, penetrating a ferruginous sandstone. It is amorphous, of a light apple-green color, translucent, greasy; hardness, 2.5; specific gravity, 2.53. After drying over sulphuric acid, it gave on analysis:

		Atomic Ratio.	
SiO_2	55.38	923	3.
NiO	17.84	238	2.04
MgO	15.62	390	
H_2O at 100° C.	5.18	288	.94
" above "	5.59	310	1.01
Fe_2O_3	.56		
	100.17		

From which it appears that this mineral has the formula

$$[\tfrac{1}{3}H_2O + \tfrac{2}{3}(Mg, Ni)O]\,SiO_2 + \tfrac{1}{3}H_2O,$$

and may be regarded as a nickel-sepiolite.

[1] Chemical News **26**, 654.

140.—ANALYSIS OF A NICKELIFEROUS TALC.

By I. A. Bachman.

Together with the foregoing specimen there was received from the same locality a ball of material which had apparently been worked to its shape by the hand when moistened with water. It is composed of minute micaceous scales, of pale yellowish green color, with a few brown particles and grains of silica scattered through it. It is readily crushed to an unctuous powder. Specific gravity 2.31. After removal of the sand and drying over sulphuric acid, analysis gave:

		Atomic Ratio.	
SiO_2	53.91	898	5.16
NiO	15.91	212	} 4.
MgO	19.39	485	
Fe_2O_3	1.46	9	
Al_2O_3	2.65	25	
H_2O at 100° C.	.80	44	} 2.01
" above "	5.50	306	
	99.62		

These figures fairly agree with the formula

$$[\tfrac{1}{3}H_2O + \tfrac{2}{3}(Mg, Ni)O]SiO_2 + \tfrac{1}{3}H_2O,$$

which is that given for hydrated talc. It is to be noted that nickel has previously been found in talc, but in small amounts; see analyses (11), (12), (27) and (35), quoted by Dana.[1]

141.—ON A FREEZING MIXTURE.

By I. A. Bachman.

The most commonly used mixture for obtaining, on a small scale, temperatures between —20° and —40° C. is that of snow and commercial hydrochloric acid. Since diluted sulphuric or nitric acid can be similarly used, it was thereby suggested that we might utilise for this purpose the mixture of equal volumes of strong nitric and sulphuric acid which had been employed in a Grove battery and for which we had little further use, frequently throwing away much of it. When first made, the

[1] System of Mineralogy, 5th ed., p. 453.

mixture of acids has a specific gravity of about 1.63, and when spent, about 1.57.

Mr. Bachman undertook to ascertain in what mixture this spent acid can be best employed for obtaining a freezing mixture. The temperature of the atmosphere in which the trials were made ranged from —2° to +2° C., and in each instance the acid was brought to the temperature of the air before mixing with the snow. Diluting the acid with differing amounts of water and mixing these with snow, it was found that the undiluted acid and that diluted with one-tenth of the volume of water gave equal diminution of temperature; any large addition of water lessened the cooling effect.

The following results were obtained:

100 cc.	acid	and	225	grams	snow	gave	fall of	31° C.
100 "	"	"	285	"	"	"	"	32° C.
100 "	"	"	340	"	"	"	"	30° C.
100 "	HCl	"	200	"	"	"	"	30° C.

As there was so little difference in the result when the snow was used within so wide limits, it was found most satisfactory to mix the snow with the acid until it attains the consistency of a thin mush, thus dispensing with all weighing. It is to be noted, as is explained by the above, that when the snow is wet, the temperature to be obtained with it is almost as low as when it is dry, which is far from being the case when hydrochloric acid is used.

It will also be seen from the above figures, that when working at a temperature near zero, the "spent acids" answer as well if not better than hydrochloric acid; but when endeavoring to obtain lower temperatures than —30° C. by previously cooling the acid, it was found that better results were obtained with hydrochloric acid.

I will add that when snow is not available I have found satisfaction in employing shaved ice for this purpose.

142.—ANALYSIS OF A HAND FIRE GRENADE.

By Chas. Catlett and R. C. Price.

The analyses of several of these "Fire Extinguishers" have been published, showing that they are composed essentially of an aqueous solution of one or more of the following bodies: sodium,

potassium, ammonium and calcium chlorides and sulphates, and in small amount borax and sodium acetate; while their power of extinguishing fire is but three or fourfold that of water.

One of these grenades of a popular brand of which I have not found an analysis was examined by Mr. Catlett with the following results: The blue corked flask was so opened as to show that it contained no gas under pressure, and upon warming its contents, but 4 or 5 cubic inches of a gas were given off. The grenade contained about 600 cc. of a neutral solution, which gave on analysis:

	In 1000 cc. grams.	In the Flask. grains.
Calcium chloride[1]	92.50	850.8
Magnesium "	18.71	173.2
Sodium "	22.20	206.9
Potassium "	1.14	10.6
	134.55	1241.5

As this mixture of substances naturally suggested the composition of the "mother liquors" from salt brines, Mr. Price made an analysis of such a sample of "bittern" from the Snow Hill furnace, Kanawha Co., W. Va., obtaining the following composition:

	In 1000 cc. grams.	In 200 cc. grains.
Calcium chloride[2]	299.70	925.8
Magnesium "	56.93	175.7
Strontium "	1.47	4.5
Sodium "	20.16	62.2
Potassium "	5.13	15.8
	383.39	1184.0

There is of course some variation in the bittern obtained from different brines, but it appears of interest to call attention to this correspondence in composition, as indicating that the liquid for filling such grenades is obtained by adding two volumes of water to one of the "bittern." The latter statement is fairly proven by the presence of the bromine, and certainly from an economical standpoint such should be its method of manufacture.

UNIVERSITY OF VA., *Sept.*, 1887.

[1] Trace of bromide.

[2] Trace of bromide.

NOTES ON PURPUROGALLIN.

By Samuel C. Hooker.

I recently observed that purpurogallin is formed in considerable quantities by the action of potassic ferricyanide on pyrogallol, and, consequently, made a few experiments to ascertain whether a better yield would result from the use of this oxidising agent than had been heretofore obtained. The great interest aroused in purpurogallin by Nietzki and Steinmann's important investigation[1] is a sufficient reason for communicating the results of these experiments, especially as I believe the method of oxidation about to be described is more satisfactory than any thus far published.

Eighty-seven grams of potassic ferricyanide are dissolved in 330 cc. of cold water, the solution filtered if necessary, and added at one operation to 20 grams of pyrogallol also dissolved in 330 cc. of cold water. Almost immediately gas is evolved, the solution loses its rich red color, and purpurogallin separates. At the end of half an hour the oxidation is complete, and the purpurogallin is filtered off, washed well with water, and dried. A yield of 13.5–14 per cent. of the weight of the pyrogallol employed can be thus obtained.

On standing, the solution deposits a further quantity of purpurogallin; this, however, is very small, and is less pure than that first obtained.

By increasing the quantity of potassic ferricyanide a somewhat larger yield can be obtained, but the purpurogallin is not as pure as when made according to the above directions.

An interesting fact, not previously observed, I believe, is the formation of purpurogallin by the oxidation of gallic acid. If a small quantity of potassic nitrite be added to a cold aqueous solution of gallic acid, the solution darkens and bubbles of gas escape. On shaking out with ether, evaporating the extract to dryness and treating the crystalline mass thus obtained with cold water, a substance resembling purpurogallin in its appearance and properties is left undissolved.

On the addition of a trace of nitric acid to purpurogallin dissolved

[1] Berichte der deutsch. chem. Gesell. **20**, 1277.

in concentrated sulphuric acid, the red color of the solution gives place to an intense violet. This reaction is extremely delicate and beautiful. With minute traces of the substance, the test is best effected by dissolving in sulphuric acid on a watch-glass and exposing for a minute or two to the fumes escaping from concentrated nitric acid. The violet color produced soon fades away. The addition of potassic nitrite to the sulphuric acid solution also gives the same intense violet.

LABORATORY OF THE FRANKLIN SUGAR REF'Y, PHILADELPHIA, *Nov.* 1, 1887.

Contributions from the Laboratory of the New York Agricultural Experiment Station.

III.—SUGARS AND STARCH IN FODDERS, AND THEIR DETERMINATION.

BY E. F. LADD.

There seems to have been but a limited number of determinations made of the percentage of sugars and starch in our numerous feeding stuffs; and during the past year I have had occasion to determine the amount in a large number of products. Some time has also been devoted to a comparison of available methods, the results of which are first considered.

Freshly prepared diastase with wheat and its products and corn meal gave an amount of starch, as determined by Fehling's solution, comparing favorably with that obtained by inversion with acid; but with hays and similar products I failed to secure any appreciable action of the diastase upon their starch content, thus rendering the method worthless for my purpose.

I then turned my attention to the inversion of the starch by means of acid, and found both hydrochloric and sulphuric acids recommended; and in order to determine which would serve my purpose best I made several parallel trials with the two acids upon starch and a number of feeding stuffs. By these preliminary trials I found that with starch rather higher results were obtained by the use of sulphuric acid, but that with hays and fodders in general

more uniform and slightly higher figures were obtained by the use of hydrochloric acid. In all these trials five grams of fodders or three grams of starch were used and 150 cc. of distilled water.

Several comparative trials were made for the most complete inversion of fodders by heating the contents in bottles tightly corked and in flasks carrying a long glass tube to serve as a condenser, but could see no appreciable difference in the results obtained upon fodders by the two methods.

Several trials were made to determine the amount of acid to use, also the time necessary for the conversion of the starch. The amount of starch inverted increased with each addition of acid up to from 3 to 5 cc. for different fodders; above this quantity up to 10 cc. no higher results were obtained than when 5 cc. were used. Several trials showed that at the end of eleven hours as much was inverted as could be obtained by prolonged heating up to fourteen hours. In order to secure uniform results with the fodders under examination I proceeded as follows:

Five grams of substance were brought upon a filter and washed with distilled water, in small quantities at a time, until the washings amounted to 200 cc. The residue[1] was dried for the starch determination. The sugar, as glucose or invert sugar, was then determined by means of Fehling's solution in 10 cc. of the filtrate. Another portion of the above washings was heated with hydrochloric acid on the water-bath for one half hour, then neutralised with sodium carbonate and the sugar determined as in the first; the difference between the two determinations being taken as sucrose or water soluble matter inverted by the acid.

The residue from the sugar determination was put in an Erlenmeyer flask of about 250 cc. capacity with 150 cc. of distilled water and 5 cc. of concentrated hydrochloric acid, and the flask closed by a cork carrying a small glass tube three and one-half feet in length, to act as a condenser. The flask was then set in a water bath kept at 100° C. for 12 hours, then allowed to stand until the following morning, filtered, made slightly alkaline with sodium carbonate, the filtrate made up to 200 cc., and the sugar determined by Fehling's solution. The starch is then easily calculated, or better by taking the readings for starch directly from a plotted chart.

[1] In a few of the earlier determinations a separate quantity of substance was taken for the starch and the sugars were deducted; but this requires unnecessary calculations, as well as being more liable to error.

In the following table are given the result of a few of the determinations for our most common feeding stuffs. In a few instances among the earlier determinations the whole was determined as starch and are so given. A few notes concerning the substances examined may be essential for a better understanding of the condition of the fodders at time of examination.

No. 1. The sample of fodder corn was taken from a lot used for ensilage.

No. 2 was taken from the field after the corn had been harvested.

No. 3 was sorghum cut for the silo.

Nos. 5 and 6 were each the average for 21 determinations at time of full bloom.

No. 7 was comfrey taken in early bloom.

No. 8 was a sample of prickly pear from Texas, cut in April.

No. 9 was the stump from same source as last, but cut at a later date.

Table Showing Percent. of Sugars and Starch in Fodders.

No.	Substance.	Invert Sugar.	Sucrose.	Starch.	Percent. of Nitrogen-free Extract as Sugars and Starch.
1	Fodder corn	9.00	0.40	13.87	53.48
2	Corn fodder	2.50	1.43	22.88	53.32
3	Sorghum	17.60	3.40	12.19	64.21
4	Alsike clover	...	...	14.63	33.81
5	Red clover, average for 21	3.88	2.48	9.38	35.40
6	Timothy, average for 21	2.23	6.21	19.72	55.69
7	Prickly comfrey	6.22	0.80	8.14	33.87
8	Cactus, top	0	5.92	9.96	30.00
9	Cactus, stump	2.80	3.60	17.10	41.12
10	Meadow hay	...	...	24.32	49.32
11	Wheat straw	...	...	22.42	59.52
12	Oat straw	...	...	23.18	51.14
13	Oats	...	...	53.20	81.05
14	Wheat	1.64	2.36	57.91	76.37
15	Wheat flour	3.64	8.36	61.88	86.77
16	Wheat middlings	3.20	6.40	41.44	75.31
17	Wheat bran	1.60	4.40	45.60	83.53
18	Ship Stuff	2.08	5.92	41.46	83.07

In the twenty-one determinations included in No. 5 for red clover the following were the variations:

	Maximum.	Minimum.
Invert sugar	5.20	2.60
Sucrose	3.80	1.20
Starch	13.90	5.58

With the timothy in the average for the 21 determinations the following for the highest and lowest were found:

	Maximum.	Minimum.
Invert sugar	5.00	2.40
Sucrose	7.60	4.68
Starch	22.61	17.55

A few determinations of the sugars and starch were made in timothy hay taken from the plats at time of full bloom, and again with samples taken from the same plats after the seeds were formed, but before they were fully matured.

The results[1] are given in the following table:

Plat.	Timothy.	Invert Sugar.	Sucrose.	Starch.	Percent. of Nitrogen-free Extract as Sugars and Starch.
VI	Early cut	3.60	6.36	22.61	62.08
VI	Late cut	2.60	4.00	22.38	55.39
XV	Early cut	3.72	5.96	18.07	52.73
XV	Late cut	2.32	5.40	21.66	60.24
XIX	Early cut	3.04	4.68	19.45	52.46
XIX	Late cut	2.00	5.20	22.61	55.69

Here we find that as the hays approached ripeness the percent. of sugars was diminished, while the starch increased.

A plot uniform in appearance in the grass fields was divided into several small plats, and various fertilizing ingredients applied as a top dressing in the spring, the purpose being to study the influence of fertilizers upon the composition of timothy grass, and the results for a few of the determinations of sugars and starch are given in the following table:

Plat.	Fertilizer.	Invert Sugar.	Sucrose.	Starch.	Percent. of Nitrogen-free Extract as Sugars and Starch.
I	Sulphate of potash .	2.40	5.88	21.20	53.05
II	Sulphate of ammonia	2.76	7.20	19.19	54.74
III	Acid phosphate . .	3.92	5.80	19.00	56.27
XIII	Lime	5.00	7.32	18.96	60.61

[1] From Agricultural Science 1, No. 10, 222.

Plat.	Fertilizer.	Invert Sugar.	Sucrose.	Starch.	Percent. of Nitrogen-free Extract as Sugars and Starch.
XIV	Gypsum	3.56	5.36	20.52	54.98
XV	Nothing	3.72	5.96	18.67	52.73
XVII	Sodium nitrate . .	3.44	5.56	20.63	56.76
XVIII	Sulphate of ammonia	3.20	6.20	17.78	51.00
XIX	Muriate of potash .	3.04	4.68	19.45	52.46
XX	Sulphate of potash .	2.96	6.00	19.72	52.79

From the preceding table we can trace no relation between the percent. of sugars and starch and the kind of fertilizer applied to the soil, nor can we say that a potash dressing increased the starch content of the timothy, as some have claimed would result from such an application.

In a study of the composition and variation in our feeding stuffs from year to year, the determination of the sugars and starch will be made, to see whether the general results of one season will be confirmed in the following year, or whether as great variation will occur as has been found for the albuminoids of grass in two successive years.

GENEVA, N. Y., *Oct.* 12, 1887.

AN IMPROVED FORM OF GAS APPARATUS.

BY J. T. WILLARD.

The description of an improved form of Elliott's apparatus for gas analysis, by J. B. Mackintosh,[1] recalls one devised by the writer. It was constructed for use in the chemical laboratory of the State Agricultural College of Kansas, and was used in an examination of the natural gases of that State by Prof. G. H. Failyer. As it embodies some advantages not combined in any other apparatus that has come under the notice of the writer, a description of it may not be amiss. It is essentially a combination of Elliott's apparatus and Frankland's apparatus for the analysis of gases

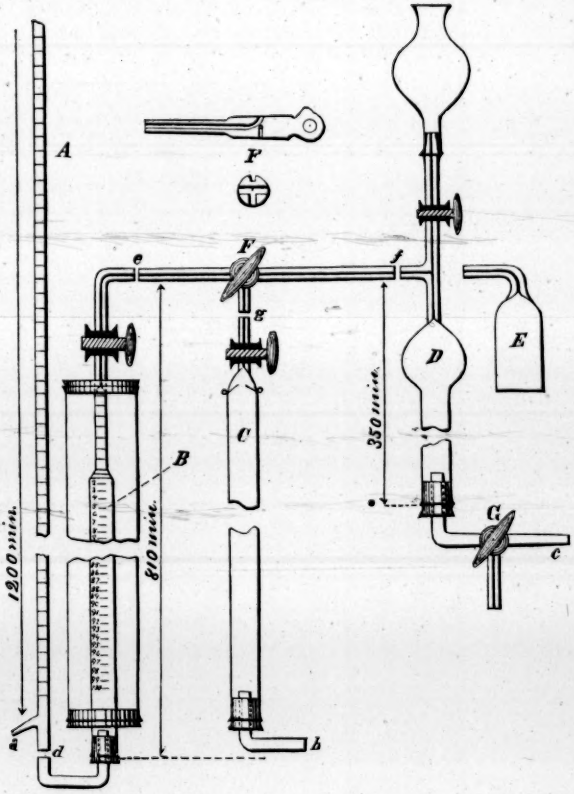
[1] This Journal **9**, 294.

incidental to water analysis,[1] with important modifications and additions. The accompanying cut will make its construction clear.

A is a pressure tube graduated in millimetres. *B* is the measuring tube holding about 120 cc., 100 cc. of which is graduated to tenths, beginning with the stopcock *F*. Its upper part is narrow, thus admitting accurate measurement of small amounts of gas as well as large. It is enclosed in a water jacket which must be provided with some means of securing a uniform temperature throughout. *C* is the explosion tube and is ungraduated. *D* is the absorption tube surmounted by a funnel for the introduction of reagents. *E* is a laboratory vessel of the ordinary kind which may be attached instead of *D* if desired. It is obvious that any form of absorption pipette may be attached at *f*. *B*, *C* and *D* are connected by the stopcock *F*, a four-way cock shown in section above. By means of this cock, the others being suitably arranged, either tube may be put in connection with either of the others or with the external air, without disturbing the other tube or tubes. *G* is an ordinary three-way cock. Reservoirs not shown in the cut are attached to the tubes by means of rubber tubing at *a*, *b* and *c*. The ends of the tubes are closed by rubber stoppers, and the several parts are connected by heavy rubber connectors at *d*, *e*, *f*, and *g*. The ends of the capillary tubes are ground squarely at these joints so that they come together perfectly. The apparatus is firmly attached to a suitable support, such as any one with a little ingenuity may devise. It is essential that *A* and *B* be so supported that their relative position shall remain unaltered. The apparatus was designed for use with mercury, but water may be used. With water the pressure tube would be unnecessary.

Concerning the mode of operating the apparatus but little need be said. It is most convenient to use Frankland's method of measuring, in which the gas operated upon is always brought to the same volume, or to an aliquot part of the original volume, by adjusting the pressure of the mercury in *A*. Points on the pressure tube corresponding to a number of convenient volumes in the measuring tube must be previously determined with care. The tensions exerted by varying amounts of gas brought to the same volume will be proportional to the amounts of gas present. If the gas is brought to an aliquot part of the original volume, the tension

[1] Journal Chem. Society **21**, 109.


A
F
e
F
f
g
D
E
C
B
350 mm.
1200 mm.
610 mm.
G
c
a
d
b

found may be reduced to that corresponding to the original volume by a very simple calculation.

The explosion of the gases is performed under reduced pressure according to the principles developed by Thomas.[1] This method of explosion is very advantageous and may be used with this apparatus, even if water is used in the tubes *B* and *D*, by filling *C* with mercury. On lowering the reservoir connected with *C* any desired degree of rarefaction may be produced. It is convenient to have a rough scale back of *C* and extending below, for use in measuring the pressure under which the gas is confined during explosion.

The fourth way in the stopcock *F* is essential for the discharge of the reagents employed in *D*; it is also used for the introduction of the gases. If it is desired to preserve a portion of the gas in *D* while another portion is being measured and exploded in *B* and *C*, it is necessary to close this external opening of *F*. This may be done simply and perfectly by filling the way with water or mercury from one of the tubes, and then slipping a short piece of rubber tubing filled with water over the end of the stopcock and closing it with a clamp.

I think no other details of manipulation need be entered into, as they are similar to those already described for other apparatus, or can be readily worked out by the operator.

The apparatus may be used for certain of the purposes to which the nitrometer has been put, such as the valuation of bleaching powder by hydrogen peroxide and *vice versa*.

The apparatus described was made in most excellent manner by Mr. Emil Greiner, of New York.

[1] Jour. Chem. Society **35**, 213.

ON THE FATTY ACIDS OF THE DRYING OILS.

By L. M. Norton and H. A. Richardson.

Linoleic acid was first carefully examined by Schüler,[1] who prepared it from linseed oil, and who ascribed to it the symbol $C_{16}H_{28}O_2$. Subsequent investigators accepted this symbol until a new investigation was made a few months since by Peters.[2] He isolated the acid with great care, and his analyses gave figures which agree with a symbol of $C_{18}H_{32}O_2$, and he found that by heating the linoleic acid with iodohydric acid he obtained stearic acid, confirming thus the symbol which he allots to it. Hazura[3] has confirmed Peters' results.

We have made a new preparation according to Schüler's method, and we find that the greatest care must be exercised in the preparation of the acid, owing to the extraordinary ease with which the acid takes up oxygen. Analysis of our acid gave the following results:

	I.	II.	III.	Theory for $C_{16}H_{28}O_2$.	Theory for $C_{18}H_{32}O_2$.
C	77.00	76.97	77.03	76.18	77.14
H	11.41	11.23	11.20	11.11	11.42

These results seem to confirm Peters' experiments, although the hydrogen still remains in doubt. We also repeated the reduction of the linoleic acid with iodohydric acid, but with different results. We obtained an acid which melted constantly at 83°, and gave the following figures upon analysis:

	I.	II.	Theory for $C_{16}H_{28}O_2$.	Theory for $C_{18}H_{36}O_2$.
C	72.07	72.20	76.05	72.00
H	13.01	12.50	12.67	12.00

At this point we were led to make an observation concerning linoleic acid which we hope may throw much light eventually on the chemistry of the drying oils. We found great difficulty in drying linoleic acid, and were finally forced to use a desiccator containing sulphuric acid, and a glass coil through which steam could be passed. By placing the watch glass containing the acid upon the coil we hoped to dry easily the acid. A current of hydrogen was passed constantly through the apparatus to prevent

[1] Ann. d. Chem. **101**, 252. [2] Monatshefte f. Chem. **7**, 552. [3] Monatshefte f. Chem. **7**, 637.

oxidation. To our astonishment, we were unable to obtain a constant weight, but the acid lost in weight to such an extent that in sixty-eight hours 20.36 per cent. of the original acid had disappeared. The ratio of decrease was regular throughout the whole time. Analysis showed that no change whatever had taken place in the composition of the substance during this time. It was evident that the acid had volatilised.

Distillation Product from Linoleic Acid.

The acid was next subjected to distillation at a reduced pressure. At about 290° at a pressure of 89 mm. a beautiful colorless product, comprising about three-fourths of the original acid, was obtained. A residue remained in the flask which has not been examined. Once prepared, the acid distills without leaving a residue. There was no evidence of decomposition during the first distillation. The product possesses a specific gravity of 0.9108 at 15° as compared with water at 4°. Several preparations were made and analysed with the results given below:

	I.	II.	III.	IV.	Theory for $C_{18}H_{28}O_2$.	Theory for $C_{20}H_{34}O_2$.	Theory for $C_{20}H_{36}O_2$.
C	78.04	77.81	78.08	78.13	76.18	78.43	77.93
H	11.39	11.81	11.57	11.73	11.11	11.11	11.67

It was found also by analysis that the first and last portions which distilled were identical in composition. The distilled acid absorbs bromine with great violence. We attempted the determination of the vapor density of the acid, and constructed a modification of Victor Meyer's vapor density apparatus, which will be described elsewhere, allowing the vapor density of bodies with a very high boiling point to be taken at any desired reduction of pressure, and obtained the following results for the distilled acid:

			Theory for $C_{20}H_{36}O_2$.	Theory for $C_{18}H_{32}O_2$.
Vapor density	151.1	152.7	154.	140.

A barium salt of the distilled acid was prepared by dissolving it in alcohol, neutralising with ammonia, and precipitating with barium chloride. The salt was rendered anhydrous by heating above 100° in an atmosphere of hydrogen, and a barium estimation made:

		Theory for $Ba(C_{20}H_{35}O_2)_2$.	Theory for $Ba(C_{18}H_{31}O_2)_2$.
Ba	18.04	18.24	19.71

These results cause us to coincide with the opinion formed by Hazura and Friedreich[1] from an examination of the action of bromine and oxidising agents upon linoleic acid, that linoleic acid, so called, is a mixture of acids. We shall investigate further these distillation products.

Ricinoleic Acid.

The volatility of linoleic acid led us to expect a similar volatility in ricinoleic acid, and our expectations were realised. The acid was prepared by the method of Saalmüller,[2] and after careful purification, analysis furnished the following results:

	I.	II.	Theory for $C_{18}H_{34}O_3$.
C	72.52	72.49	72 48
H	11.51	11.36	11.41

The specific gravity of the acid was 0.9502 at 15° compared with water at 4°. This acid was subjected to distillation at a pressure of 20 mm. A liquid of a light yellow color came over freely between 240° and 260°, while a non-volatile residue constituting about one-fourth of the original acid remained in the flask. This residue solidified upon cooling. The liquid was an acid, and possessed the specific gravity of 0.912. After redistillation the analysis gave:

	I.	II.	Theory for $C_{20}H_{36}O_2$.
C	78.20	78.03	77.93
H	11.69	11.65	11.67

The vapor density of the distilled product was as below:

		Theory for $C_{20}H_{36}O_2$.
Vapor density	150.1	154.

This product appears at the present time to be identical with that furnished by the distillation of linoleic acid. It will be further investigated. We are led to believe that ricinoleic acid also is not a homogeneous substance. We propose to examine the distillation products of the acids of the drying oils.

Institute of Technology, Boston.

[1] Monatshefte f. Chem. **8**, 164.

[2] Ann. d. Chem. **64**, 108.

Contributions from the Chemical Laboratory of the University of Cincinnati.

XXXI.—ON THE OCCURRENCE IN NATURE OF COPPER ANTIMONIDE.

By A. Laist and T. H. Norton.

Combinations of copper and antimony have hitherto been known only in the form of the four alloys prepared by Calvert and Johnson,[1] and Christofle.[2] Recently a large deposit of an antimonide of copper has been discovered in the eastern part of Asia Minor, not far from Mytilene. We are indebted to the courtesy of Mr. Archag Melcon for samples taken from an extensive vein underlying the entire area of a Turkish village, and easily accessible from the surface.

The new mineral resembles native silver in color. The freshly fractured surface is quite lustrous, but tarnishes easily, especially in air containing sulphuretted hydrogen. It is of massive structure; no traces of crystallisation or distinct planes of cleavage being detected. It is quite brittle, with very uneven fracture, and in hardness it stands between fluor spar and apatite, *i. e.* on the scale 4–5. The fusibility in the reducing flame lies between that of antimony glance and of natrolite.

The high specific gravity of the mineral is its most striking physical characteristic. This was found to be 8.812 as the mean of three closely agreeing determinations. It is worthy of note that but a limited number of minerals possess a higher specific gravity.

A qualitative examination showed the sample of the mineral to be a perfectly pure compound of copper and antimony, free from other metals, and also free from gangue.

The quantitative analyses gave the following results:

	I.	II.	III.	Average.
Cu	73.45	73.74	72.92	73.37
Sb	27.05	26.90	26.62	26.86
	100.50	100.64	99.54	100.23

The analytical results give figures lying between those required

[1] Phil. Mag. (4) **18**, 354.

[2] Combinaisons de l'antimoine avec les métaux. Göttingen, 1863.

by the two simple molecular expressions Cu_5Sb and Cu_6Sb, and approximate still more closely to the combination $Cu_{11}Sb_2$.

Cu_5Sb.	Cu_6Sb.	$Cu_{11}Sb_2$.	Found.
72.42	75.6	74.39	73.37
27.58	24.4	25.61	26.86

It will be seen that the composition of this copper antimonide is not far removed from the stibio hexargentite variety of dyscrasite, the only native antimonide hitherto known, which Petersen[1] has shown to exist in two well defined forms, Ag_3Sb and Ag_6Sb.

It seemed a matter of interest to prepare an artificial alloy of copper and antimony of the same composition as the mineral just described. Accordingly two hundred grams of copper and seventy-four grams of antimony were fused together in a clay crucible and allowed to cool slowly. The regulus obtained weighed a few decigrams less than two hundred and seventy-four grams, and its composition therefore was copper 73 per cent., antimony 27 per cent.

In appearance it closely resembled the native mineral, although not quite so lustrous. It was also more brittle, probably on account of a more rapid congelation. The specific gravity was 8.829; very slightly higher than that of the mineral, 8.812.

It may be mentioned in this connection that the specific gravity of this antimonide is notably higher than the theoretical figure for a mixture of copper and antimony in the proportions given, viz. 8.19, the difference being 0.622.

A similar fact was noticed by Calvert and Johnson[2] when experimenting on a combination of the two metals represented by the formula CuSb. The specific gravity found was 7.99, while that calculated was 7.38; difference 0.61.

With regard to the metallurgical utilisation of the large Asiatic deposit of this copper antimonide, it is doubtful whether the expense attendant upon the separation of the two metals would permit of successful competition on the one hand with stibnite and on the other hand with the abundant American deposits of copper minerals. Probably the simplest method of treating the mineral would be to expose it to the action of hot dilute sulphuric acid, which would dissolve out the copper and leave an insoluble

[1] Pogg. Ann. **137**, 377. [2] Phil. Mag. (4) **18**, 354.

residue of antimony oxide. Experiment shows us that if an excess of the acid be avoided, all of the copper is extracted and but a slight amount of antimony enters into solution.

Several alloys containing copper and antimony are used in the arts, and the mineral on account of its purity could be used directly in their preparation.

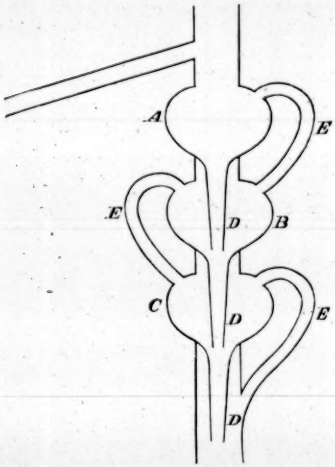
This new mineral is named horsfordite, in honor of Professor Horsford, formerly Rumford Professor of Chemistry at Harvard University.

XXXII.—ON A NEW APPARATUS FOR FRACTIONAL DISTILLATION.

By T. H. Norton and A. H. Otten.

In his ingenious apparatus for the technical transformation of ammonium sulphocyanide into calcium sulphocyanide (Wurtz, Dictionnaire de Chimie, Supplément, p. 597), Dr. J. Tcherniac introduced an interesting feature, the so-called *déverseur*, designed primarily to prevent the frothing accompanying the rapid distillation of the ammoniacal liquor. This *déverseur* consisted simply of a cylinder about two-thirds of the size of the retort containing the mixture of lime and solution of ammonium sulphocyanide, and was situated above this retort. The bottom of the cylinder was connected by a pipe with the bottom of the retort, while pipes from the upper portion connected with the top of the retort and with the condensing apparatus. The practical result of this arrangement was that the vapors from the retort entered the top of the cylinder by one opening, and left it by another opening for the condenser, while all liquid carried along mechanically, dropped to the bottom of the cylinder and returned to the retort.

Distillation is carried on so easily and rapidly by means of this device that it seemed a matter of interest to experiment upon the adaptation of this principle of construction to the wants of the laboratory in the form of an apparatus for fractional distillation. We are indebted to Dr. Tcherniac for a glass model embodying the essential features of the apparatus just described, the details of which will be easily understood from the accompanying cut.



The three bulbs *A*, *B* and *C* are connected with each other by the curved tubes *E E E*, the lowest connection entering the stem of the apparatus. Small tubes *D D D*, 2 mm. in diameter, likewise project from the bottom of each bulb. Their capillarity is increased by passing a platinum wire through the entire series. When the device is inserted into a distilling flask, it will be seen at once that the current of vapor takes a zig-zag course, passing through the tubes *E E E*, and across the top of each bulb, while all condensed liquid returns directly by the route of the tubes *D D D* into the distilling flask. A fractional distillation performed by means of this apparatus would hence be conducted on principles directly contrary to those which underly the construction of our ordinary technical and laboratory stills, in which the central object is to bring the ascending current of vapor into as intimate contact as possible with the downward flow of liquid resulting from the condensation of less volatile constituents.

In order to test the availability of the new design we brought it into direct comparison with two well known types of fractionating apparatus, viz. those of Hempel and of Linnemann, both based on

the ordinary principle of a thorough washing of the vapor current by the products of partial condensation.

The Linnemann apparatus used consisted of a tube 1 cm. in diameter, with three bulbs blown along a space of 16 cm., and contained three cups of platinum gauze. The Hempel apparatus consisted of a similar tube, the cups being replaced by a layer of glass beads 7 cm. deep.

The new device contained three bulbs blown on a tube 1 cm. in diameter along a space of 12 cm. as described above. Comparative fractional distillations were conducted with several mixtures of known quantities, every precaution being taken to render the conditions identical in the different series. In all cases 100 cc. of liquid were used, and the fractions were collected at intervals of 3° in graduated cylinders. After each addition, during the fractionation, of a new quantity of liquid, fractions were collected during the two preceding temperature intervals.

The quantities given are in cubic centimetres. The first column, A, gives the results obtained with the Linnemann apparatus; the second column, B, those with the Hempel apparatus, and the last column, C, those with the new apparatus.

First Series.

Mixture of 50 cc. of acetone (96 per cent.), boiling point 56°–57°, and 50 cc. of methyl alcohol, boiling point 66.6°.

First Fractionation.

	A.	B.	C.
56–59°	31	40	33
59–62	46	38	39
62–65	14.5	12.5	16.5
65–67	8	8.5	11
	99.5	99	99.5

Second Fractionation.

	A.	B.	C.
56–59°	46.5	53	47.5
59–62	28	24.5	23.5
62–65	8	9.5	11
65–67	14.5	11.5	16.5
	97	98.5	98.5

Third Fractionation.

56–59°	51	58.5	50.5
59–62	19.5	18.5	18
62–65	6.5	8	7.5
65–67	18	13	20
	95	98	96

Fourth Fractionation.

56–59°	57	61.5	55
59–62	11.5	13	13.5
62–65	6.5	7.5	6
65–67	18	14.5	21
	93	96.5	96.5

Fifth Fractionation.

	A.	B.	C.
56–59°	58	63	55.5
59–62	9.5	12.5	12
62–65	5	5.5	4.5
65–67	20	14.5	24.5
	92.5	95.5	94.5

SECOND SERIES.

100 cc. crude wood alcohol.

First Fractionation.

63–66°	48	45.5	46.5
66–69	30.5	33	31.5
69–72	12.5	16.5	13
72–75	4	1.5	6.5
75+	2.5	1	2
	97.5	97.5	99

Second Fractionation.

63–66°	57	50.5	52.5
66–69	26	30	27
69–72	6	12.5	11.5
72–75	3.5	1.5	4
75+	3.5	0.5	3.5
	96	95	98.5

Third Fractionation.

63–66°	60	56.5	61
66–69	24.5	30	21.5
69–72	6	6	8
72–75	2	1	2
75+	3	0.5	4.5
	96	94	97

Fourth Fractionation.

63–66°	70.5	64.5	71
66–69	16	21.5	14
69–72	3.5	6.5	5.5
72–75	2	1	2
75+	3	0.5	3.5
	95	94	96

Fifth Fractionation.

63–66°	74.5	65.5	75.5
66–69	13	20.5	11
69–72	3.5	6	5
72–75	1	1	1
75+	3	0.5	3.5
	95	93.5	96

Third Series.

Mixture of 50 cc. of ethyl alcohol, boiling point 78.3°, and 50 cc. of water, boiling point 100°.

First Fractionation.

	A.	B.	C.
79–82°	27	29.5	27
82–85	16.5	16.5	18
85–88	8	8.5	6.5
88–91	5	5	5
91–94	6	3.5	4
94–97	3.5	3.5	4.5
97–100	32	31.5	32
	98	98	97

Second Fractionation.

	A.	B.	C.
79–82°	33	42.5	39
82–85	13.3	7	8.5
85–88	4.5	4	5
88–91	4.5	2.5	3.5
91–94	1	1.5	2.5
94–97	1.5	1	1.5
97–100	39.5	38	38
	97	96.5	97

Third Fractionation.

79–82°	43.5	46	43
82–85	4.5	4.5	6
85–88	4	3	3.5
88–91	0.5	1	2
91–94	0.5	0	0.5
94–97	0.5	1	0.5
97–100	41.5	41	41
	95	96.5	96.5

Fourth Fractionation.

79–82°	46.5	49	47
82–85	4	3	4
85–88	2	2	2.5
88–91	0	0	0.5
91–94	0	0	0
94–97	0.5	1	0.5
97–100	42.5	41	42
	95.5	96	96.5

Fifth Fractionation.

79–82°	50	51	49
82–85	1.5	2	3.5
85–88	0	0.5	0
88–91	0	0	0
91–94	0	0	0
94–97	2	2	1.5
97–100	43	40.5	42.5
	96.5	96	96.5

FOURTH SERIES.

Mixture of 50 cc. of toluene, boiling point 110°, and 50 cc. of amyl alcohol, boiling point 131°.

First Fractionation.

	A.	B.	C.
108–111°	40	42.5	43
111–114	20.5	19.5	15.5
114–117	6	9	9.5
117–120	2	4	5.5
120–123	2	5	4.5
123–126	5	4	4.5
126–129	22.5	14	16
	98.5	98	98.5

Second Fractionation.

	A.	B.	C.
108–111°	49	42.5	47
111–114	8.5	11.5	10
114–117	4	7	6.5
117–120	3.5	5	4
120–123	3	4	3.5
123–126	3.5	4	3
126–129	26	23	23
	97.5	97	97

Third Fractionation.

108–111°	50	44	50
111–114	6	9.5	7
114–117	3.5	5.5	4
117–120	2.5	4	2.5
120–123	2.5	4	2
123–126	1.5	3.5	4.5
126–129	31	27	26
	97	97.5	96

Fourth Fractionation.

108–111°	52	48.5	53
111–114	4	5.5	3.5
114–117	2.5	7	3
117–120	2	1.5	3
120–123	1.5	3	3.5
123–126	1.5	3	1.5
126–129	33	29	27.5
	96.5	97.5	95

Fifth Fractionation.

108–111°	53	47.5	55
111–114	3.5	7.5	3
114–117	3	3	2.5
117–120	0.5	4	1.5
120–123	0.5	1	1
123–126	2.5	2.5	1.5
126–129	34	31	31
	97	96.5	95.5

FIFTH SERIES.

Mixture of 50 cc. of benzene, boiling point 80.5°, and 50 cc. of toluene, boiling point 110°. (In this series the Linnemann tube

(A) was provided with six platinum gauze cups, instead of three, as in the preceding series.)

First Fractionation.

	A.	B.	C.
81–84°	30	25	20
84–87	8	10.5	13
87–90	11	8	7
90–93	5	10.5	10
93–96	4	4	6.5
96–99	3	5	8.5
99–102	3	4	5
102–105	7.5	5.5	5
105–108	10	9	7
108–111	13	14.5	14
	94	96	96

Second Fractionation.

	A.	B.	C.
81–84°	32	37	28
84–87	10.5	7	6.5
87–90	5	6.5	6.5
90–93	5	4	6.5
93–96	3	1	6
96–99	2.5	3.5	5
99–102	2	4	4.5
102–105	4.5	5	6.5
105–108	6	6.5	7
108–111	21	20	18
	91.5	95	94.5

Third Fractionation.

	A.	B.	C.
81–84°	38	39	32
84–87	3.5	6	5
87–90	5	4	6
90–93	4	3.5	5.5
93–96	3	1.5	4.5
96–99	2	2	2
99–102	1	3	3.5
102–105	2	4.5	4.5
105–108	4.5	5.5	6.5
108–111	27	23	24
	90	93	94

Fourth Fractionation.

	A.	B.	C.
81–84°	41	41.5	34.5
84–87	4	4	5
87–90	4	3	4.5
90–93	3	4	4.5
93–96	2.5	2	2.5
96–99	0.5	2	3.5
99–102	1	1	2.5
102–105	2.5	2.5	3.5
105–108	3.5	4	4
108–111	29	26	27
	90	90	91.5

Fifth Fractionation.

81–84°	43	44.5	37
84–87	3	3.5	3.5
87–90	2	2.5	3.5
90–93	1	1	2.5
93–96	0	1	2.5
96–99	2.5	1	2
99–102	0	1.5	1.5
102–105	2.5	2.5	2.5
105–108	5.5	3.5	5
108–111	28	28.5	28.5
	88	89.5	88.5

These experimental data are of interest as showing that no one form of apparatus is superior to other forms for all cases. Thus in the series of distillations of mixtures of acetone and methyl alcohol, larger fractions of the latter constituent are separated by the use of the new apparatus than by the use of the other two forms. Hempel's apparatus yields a larger fraction at the boiling point of acetone in the above case than either of the other forms, while on the contrary, in the case of wood spirit, its initial and terminal fractions are both inferior in amount to those of the other forms. Again, in the distillation of a mixture of alcohol and water there appears to be but slight difference in the effects obtained by the three forms. In the case of a mixture of benzene and toluene, the two older structures permit the separation of decidedly larger benzene fractions, while the toluene fractions are about the same in all cases. When the toluene is mixed with amyl alcohol the new apparatus gives better results with the lower fraction than the other two forms, while it is behind them in the separation of the alcohol.

As far as the power of rapid fractionation is concerned, the new form of apparatus, while giving results quite as satisfactory as those yielded by the two types hitherto regarded as the most efficient, certainly does not exceed them in the average thoroughness of separation.

With regard to the simplicity of construction Hempel's apparatus still remains unsurpassed, while the lateral tubes of the new form render this type certainly more fragile than the original Linnemann apparatus, and place it rather in the category of such a device as that of Le Bel and Henninger.

Although the new type cannot claim advantages which should lead to its superseding the present forms of apparatus for fractional distillation, the experiments made with it show conclusively that the principle involved in its construction, of the rapid separation of vapor and condensed liquid, yields at least as satisfactory results in practice as the totally opposite principle of a continuous washing of vapor in condensed liquid.

XXXIII.—ON THE ALLOYS OF CALCIUM AND ZINC.

By T. H. Norton and E. Twitchell.

A method for obtaining an alloy of calcium and zinc was briefly described in 1860 by Caron.[1] It consisted in heating together in a closed crucible a mixture of 3 parts calcium chloride, 4 parts zinc, and 1 part sodium. Caron states that by this process he was able to prepare alloys containing from 10 to 15 per cent. of calcium.

With the desire of examining these alloys more closely and of testing their availability for the production of metallic calcium, the following experiments were instituted.

In three cases the proportions indicated by Caron were used. In two cases the amount of zinc was diminished by one half. The calcium chloride was first fused, and after congelation finely powdered. The zinc was introduced in the form of small clippings of sheet zinc, and the sodium in small fragments. The mixture was placed in a covered French clay crucible and heated in a furnace or muffle. When zinc flames appeared the temperature was reduced so as to cause a steady but slight volatilisation of zinc. After the lapse of 15-30 minutes the crucible was withdrawn from the fire and broken when cool. The alloy was found at the bottom in the form of a regulus.

The determination of the calcium in the alloys was made in some cases by the use of the "cyanide method," the zinc salt being removed from the mixture of precipitated zinc and calcium carbonates by treatment with a solution of potassium cyanide. In other cases the hydrochloric acid solution was precipitated by ammonia and ammonium sulphide and allowed to settle, when the calcium was precipitated as oxalate from an aliquot portion of the clear liquid.

Experiment I.

The mixture of 40 grams zinc, 30 grams calcium chloride, and 10 grams sodium was strongly heated for 15 minutes. Zinc flames then appeared and the temperature was reduced. After further heating for 15 minutes, during which time puffs of zinc vapor were given off, the crucible was removed. The regulus weighed 18 grams. An analysis by the cyanide method gave

Ca 2.28

[1] Comptes rendus **50**, 547.

The specific gravity was 6.8, and the melting point 360° (the melting point of zinc). This alloy was difficult to distinguish from pure zinc. It was malleable, and had the same crystalline structure as zinc. The low percentage of calcium was evidently due to the maintenance of too high a temperature during the operation.

Experiment II.

Mixture of 20 grams zinc, 30 grams calcium chloride, and 10 grams sodium. The crucible was introduced into a muffle already heated to a bright red heat. After 25 minutes the crucible was removed. A zinc flame had been apparent during the entire time.

The regulus weighed 21.6 grams.

The analysis made by the sulphide method gave

Ca 5.44

The melting point was about 640°, coinciding very closely with the melting point of potassium iodide, which was used for a comparative determination. The hardness was 3½.

Experiment III.

The same quantities were used as in the preceding experiment. The muffle was kept for 25 minutes at such a temperature that zinc flames were not evident except when the cover of the crucible was raised.

The regulus weighed 20.7 grams.

The analysis made by the sulphide method gave

Ca 6.06

The specific gravity was 6.115. Melting point about 640°. Hardness 3½. This alloy was of a shining white color and quite brittle. The lustre did not become dull in the air at the ordinary temperature. At higher temperatures, but still far below the melting point, it oxidised rapidly. It was not attacked by cold water.

Experiment IV.

The same proportions as in the first experiment were used. The crucible was heated in an open furnace for 30 minutes, zinc being sparingly volatilised during the entire time.

The regulus weighed 39.7 grams.

The analysis by the cyanide method gave

Ca 4.97

The specific gravity was 6.24. Melting point about 640°. Hardness 3½. This alloy had the same physical properties as that obtained in the third experiment. It possessed, however, a marked granular crystalline structure.

Experiment V.

The same charge was used as in the preceding experiment. The crucible was kept in the furnace for 40 minutes, a slow volatilisation of zinc being constantly maintained.

The regulus weighed 41 grams.

The analysis by the cyanide method gave

Ca	6.36.

The specific gravity was 6.369.

The alloy closely resembled that obtained in the third experiment.

Experiments were made to obtain alloys richer in calcium by igniting samples of the alloys already described in porcelain crucibles, in a current of hydrogen so as to expel the zinc. In all cases, however, although zinc was driven off in notable amounts, still there was a proportionate loss of metallic calcium. The residual alloy rich in calcium was left in so spongy a condition that it oxidised immediately in contact with the air, and the crucibles likewise showed traces of being attacked.

The results of these experiments would tend to show that it is exceedingly difficult, if not impossible, to obtain by Caron's method zinc-calcium alloys containing more than 6–7 per cent. of the latter metal. The notable raising of the melting point, due to the addition of small amounts of calcium to zinc, is worthy of attention.

NOTES.

A Simple Method of determining Equivalents for Use with Large Classes of Students.

I do not think it advisable, generally speaking, to introduce students to equivalents, atoms, molecules, etc., until they are pretty well advanced and tolerably expert analysts. The first term's work in this laboratory is always on the metals, and the aim of the work is to accumulate results as rapidly as possible, and to familiarise the student with as many substances as possible. I believe this to be a method that prepares the mental system for theory when the time comes for it. While the freshman class were studying the action of hydrochloric acid on metals, it was noticed by some of them that some metals apparently liberated more hydrogen than others. This observation aroused considerable interest, and I thought it would be well to introduce the equivalent then and there.

The question was put as follows: *What weight of each metal will it take to liberate one milligram of hydrogen?*

The metals chosen for experiment were iron, zinc, and aluminium. The apparatus given to each student consisted of a 3-inch evaporating dish and a common 6-inch test tube. In some cases graduated gas tubes were given out. 50 to 100 milligrams of the metal having been accurately weighed, the test tube was filled with acid (in most cases hydrochloric acid), and inverted in the evaporating dish, previously one-third filled with the same acid. The piece of metal was now quickly brought under the tube and the whole apparatus left to itself till the solution was complete. Sometimes a gentle heat was applied. Later on it was found better to put the metal in a little cup (made by cutting off ½ inch from the lower end of a small test tube) before bringing it under the tube, thus avoiding the possibility of bubbles being carried out by the descending current of acid. When solution was complete the tube was transferred to a large jar of water and the acid displaced by water. It was then cooled to the temperature of the room.

When graduated tubes had been employed the volume could then be read directly, the necessary corrections for temperature and pressure made, and the equivalent deduced. When ordinary test tubes had been employed, the line where gas ended and water began was marked on the tube by tying a piece of fine thread round it. Water was then run in from a carefully graduated

burette till the space previously occupied by gas was occupied by water. The volume thus obtained represented the volume of gas obtained, and was corrected for temperature and pressure as usual.

I acknowledge the apparent crudeness and roughness of the process, but invite attention to the following results:

Iron.	Zinc.	Aluminium.
28.2	32.68	9.006
27.8	32.65	9.004
27.69	32.46	9.004
27.78	32.36	9.000
27.74	32.52	9.000
27.75	32.40	9.03
27.93	32.60	8.995
28.03	32.45	8.988
28.11	32.48	9.07
27.90	32.35	8.887
27.89	32.50	9.100
27.80	32.39	9.12
27.85	32.22	9.010
27.97	32.62	
	32.46	

In some cases duplicate results are given, but where two results are identical, they are given because they were separate results obtained by different students.

In such a crude process there are so many apparent sources of error that space would forbid a discussion of them, and I will only say that I believe the small quantities operated on cause many errors to vanish. The materials were all the purest obtainable. Great care was taken in marking and reading volumes. When heat had been used, and indeed in almost every case, the tube was, after the acid had been displaced by water as previously stated, shaken so as to absorb most of the hydrochloric acid volatilised. The gas was usually allowed to stand for some time before being read. The burettes had been carefully compared with a calibrated standard, and any error in any one of them was not large enough to have affected the results materially.

There is of course nothing new about the process, but I have never seen any published results of its use with large classes.

Most of the work as to finding the best way of carrying out the process has been done by my Freshman class, some of whom have attained considerable skill in working it. The process as here presented is the best we have done so far.

When graduated tubes were employed the results were not as good. I think it was because the volume of gas and quantity of metal were great enough to be more appreciably affected by the inherent errors of the process. It should be said that the level of

the water in the tube was always brought to the level of the water in the jar before reading the volume, and that the tube was left standing long enough to get to the temperature of the room after being placed in position.

JOSEPH TORREY,
Professor of Chemistry in Iowa College.

Syntheses in the Fatty Series by Means of Aluminium Chloride.

In the laboratory of Friedel a very successful condensation in the fatty series by means of aluminium chloride has lately been carried out by Combes. This chemist observed that acetyl chloride treated with aluminium chloride yields a solid body which contains aluminium. He explains the formation of this compound by the following equation: $6(C_2H_3OCl) + Al_2Cl_6 =$

$$\left(CH_3-CO-CH_2-CO-CH_2-C\begin{matrix}Cl\\O\\Cl\end{matrix}\right)_2Al_2Cl_4 + 4HCl.$$

By the action of water the aluminium compound is destroyed and acetyl-acetyl-acetic acid, $CH_3-CO-CH_2-CO-CH_2-COOH$, is set free. The latter, however, decomposes spontaneously into carbonic acid and acetylacetone, $CH_3-CO-CH_2-CO-CH_3$.

The mechanism of the reaction between aluminium chloride and acetyl chloride is not fully explained by Combes; the resulting acetylacetone is, however, distinctly characterised as such by a series of reactions. Thus the new compound does not undergo any change when boiled with phosphorus trichloride and acetyl chloride, which demonstrates the absence of hydroxyl. By the action of hydroxylamine and phenylhydrazine, the oximes and a phenylhydrazine compound,

$CH_3-C(NOH)-CH_2-CO-CH_3$,
$CH_3-C(NOH)-CH_2-C(NOH)-CH_3$,
$CH_3-C=N-NHC_6H_5-CH_2-C=N-NHC_6H_5-CH_3$

were obtained. These reactions establish without doubt the fact that the new compound is a diacetone. Phosphorus pentachloride changes it into the chloride, $CH_2=CCl-CH_2-CCl=CH_2$, which on treatment with alcoholic potash yields the ethyl-ether of a hydrocarbon, $CH\equiv C-CH_2-C(OC_2H_5)=CH_2$. The hydrocarbon itself, $CH\equiv C-CH_2-C\equiv CH$, is not stable.

By the action of sodium amalgam in acid solution on acetylacetone, the normal symmetrical bisecondary amylglycol, $CH_3-CHOH-CH_2-CHOH-CH_3$, can be easily obtained; and simultaneously the pinacone, $CH_3-COH-CH_3$

$CH_3-COH-CH_3$, and the anhy-

dride of a tetratomic alcohol, which should be called diamyl diglycol,

$$CH_3-COH-CH_2-COH-CH_3$$
$$\quad\quad|\quad\quad\quad\quad|$$
$$CH_3-COH-CH_2-COH-CH_3,$$

$$CH_3-COH-CH_2-C-CH_3$$
$$\quad\quad|\quad\quad\quad\quad|>O$$
$$CH_3-COH-CH_2-C-CH_3,$$

are formed by incomplete reduction of the acetylacetone.

Continued action of chlorine or bromine on acetylacetone produces a hexa-substitution-product as $CCl_3-CO-CH_2-CO-CCl_3$. It has been found impossible to substitute by halogens the two hydrogen atoms in the CH_2 group which is between the two CO groups. Those two atoms behave therefore like the hydrogen atoms in the hydroxyls of an acid. They cannot be substituted by the direct action of halogens. By sodium, however, they are very easily replaced; by the action of alkyl iodides on the sodium compounds thus obtained, sodium can be replaced by alkyls.

Hydriodic acid reacts easily with acetylacetone. By its action on the latter compound, Combes obtained the di-iodo-derivative corresponding to the normal symmetrical bisecondary amylglycol, $CH_3-CHI-CH_2-CHI-CH_3$; further, the iodine-derivative of secondary normal amyl alcohol, $CH_3-CHI-CH_2-CH_2-CH_3$, and lastly, normal pentane, $CH_3-CH_2-CH_2-CH_2-CH_3$. Hitherto it has been very difficult to obtain normal pentane in a state of purity, as it had to be prepared by fractional distillation from American petroleum. The reaction of Combes now makes it possible to prepare this compound on a large scale and in a state of perfect purity.

By treating with alcohol, instead of water, the compound which is formed in the reaction between aluminium chloride and acetyl chloride, Combes obtained the ethyl-ether of acetyl-acetyl-acetic acid, $CH_3-CO-CH_2-CO-CH_2-COOC_2H_5$, and thus proved that his hypothesis regarding the formation of acetylacetone from acetyl-acetyl-acetic acid is correct. Acetyl-acetyl-acetic acid has been characterised as such by the formation of the hydrazine compound. $CH_3-C(N-NHC_6H_5)-CH_2-C(N-NHC_6H_5)CH_3-COOC_2H_5$.

Sodium acts energetically upon acetyl-acetyl-acetic ether, but it has not yet been proved in which CH_2 group substitution by sodium takes place.

Combes has further shown that aluminium chloride reacts in the same way with butyryl, propyryl, isobutyryl and valeryl chloride. Thus this new reaction makes it possible to prepare synthetically a very large number of compounds, which up to date have either been entirely unknown or very difficult and costly to prepare.—(*Ann. chim. phys.*, October, 1887.) E. A. S.

Provisional List of Abbreviations of Titles of Chemical Journals.

The committee of the American Association for the Advancement of Science, known as the Committee on Indexing Chemical Literature, in their last report suggested the following abbreviations of titles of chemical journals. It will be of material assistance, if writers on chemical subjects will generally adopt the suggestions of the Committee. The abbreviations will hereafter be used in this journal:

1. Afh. Fys. Kemi.
2. Agenda chim.
3. Chem. Ztg.
4. Allg. chem. Bibl. (Trommsd.)
5. Allg. J. Chem. Scherer.
   a N. allg. J. Chem. Gehlen.
   b J. für Chem. Gehlen.
   c J. für Chem. Schweigger.
   d J. prakt. Chem.
6. Alm. di chim. agric.
7. Alm. de chim.
8. Alm. Scheid. Apoth.
   a Taschenb. f. Scheid.
9. Am. Chem. J.
10. Am. Chemist.
11. Am. Lab.
12. Analyst.
13. Ann. Chem. (Liebig).
14. Ann. chim. phys.
15. Ann. di chim. (Brugnatelli).
16. Ann. fis. chim.
17. Ann. Chem. Med.
18. Ann. Chem. Phil.
19. [Refer to 14].
20. Ann. Chym. Pract. Pharm.
21. Ann. Pharm. Bastick.
22. Ann. Phil. (Thomson).
23. Annuaire prod. chim.
24. Annuaire chim.
25. Annuaire sci. chim.
26. Annual Rep. Chem.
27. Anno. alm. pei chim.
28. Anno. chim. ital.
29. Anno. scienze chim. nat.
30. Anno. scienze chim. farm.
31. Anti-Adult. Rev.
32. Arch. der Agr.-Chem.
33. Arch. for Pharm. Trier.
34. Arch. ges. Naturl.
35. Arch. für theor. Chem.
36. Arch. thier. Chem.
37. Arsb. Phys. Chemi.
38. Ausw. Abh. Chem. Crell.
39. Ausw. Ann. Chem. Crell.
40. Beitr. Chem. Wasserberg.
41. Beitr. Min. Klaproth.
42. Beitr. Chem. Bucholz.
43. Arch. für physiol. chem.
44. Ber. d. chem. Ges. (*or* Ber.)
45. Berl. Jahrb. Pharm.
46. Bibl. phys. Lit. (Hermbstädt).
    Ann. Chem. Lit.
47. Boston J. Chem.
48. J. de pharm.
49. Bull. math. chim. (Férussac.)
50. Casopis chem.
51. Centrbl. Agr.-Chem.
52. Chem. Gaz.
    Chem. News.
53. Chem. News. Am. Repr.
54. Chem. Record. (Lond.)
55. Chem. Rev. (Lond.)
56. Am. Chem. Rev.
57. Chem. Kal.
    a Techn.-chem. Jahrb.
58. Chem. Ackersmann.
59. Chem. Ann. Crell.
60. Chem. Ind. (Jacobsen.)
61. Chem. phys. oefen.
62. Chem. Archiv Crell.
63. Chem. J. Crell.
64. Chem.-pharm. archief.
65. Chem. techn. Mitthl.
66. Chem. techn. Repert.
67. Chemist. Mongredieu.
68. Chemist. Watt.
69. Chem. and Drug.
70. Chem. Advocate.
71. Chem. and Meteor. J. (Amherst.)
72. Chem. Desk Comp.
73. Chemists' J.
74. Chimiste, Bruxelles.
75. Chimiste, Paris.
76. Compt. rend. *or* C. R.
77. C. R. chim. Montpellier.
78. Crell's Chem. J. Lond.
79. Deutscher Chem. Kal.
80. Edinb. J. Sci.
81. Fortschr. techn. Chem.
82. Fortschr. theor. Chem.
83. Fortschr. Chem. Köln.

84. Gazz. chim. ital.
85. Gazz. chim. techn. (Sembenini).
86. Gazz. farm. (Sembenini).
87. Gazz. farm. chim. (Venezia).
88. Giorn. fis-chim. ital.
89. Giorn. chim. veterin.
90. Giorn. farm. chim. (Gajani).
91. Giorn. di farm. Chiappero.
92. Giorn. di farm. Cattaneo.
    a Bibl. di farm.
    b Ann. di farm. appl. (Polli).
93. Giorn. di fis. Majocchi.
94. Giorn. di fis. Brugnatelli.
95. Obs. sur. phys.
    a J. de phys.
96. Jahrb. Erfind.
97. Jahrb. ökon. Chem.
98. Jsb. Agr.-chem. (Ditmer).
99. Jsb. rein. Chem.
100. Jsb. Agr. Chem.
101. Jsb. chem. Techn. (or Wagner's Jsb.)
102. Jsb. phys. Wiss. (or Berzelius' Jsb.)
103. Jsb. Chem.
104. Jsb. thier. Chem.
105. J. chim. phys. Van Mons.
106. J. chim. med.
107. J. chim. Van Mons.
108. J. der Pharm. Trommsd.
109. J. der Phys. Gren.
    a N. J. der Phys. Gren.
    b Ann. der Phys. Gren.
    c Ann. der Phys. Gilbert.
    d Ann. der Phys. Pogg.
    e Ann. der Phys. Wied.
    f Beibl. Ann. der Phys.
110. J. Phys. Krönig.
111. J. techn. Chem.
112. J. Appl. Chem.
113. Nicholson's J.
114. J. Soc. Chem. Ind.
115. K. phys. chem. Abh.
116. Ztschr. Chem.
117. Laboratorium.
118. Laboratory, Boston.
119. Laboratory, Lond.
120. Listy chem.
121. Mag. f. Apoth. (Elwert.)
    a Repert. f. Chem (Elwert.)
122. Mag. höhere Naturw.
123. Mech. and Chem.
124. Mél. phys. chim.
125. Mem. prat. chim.
126. Mem. Columb. Chem. Soc.
127. Misc. chim. fis. (Pisa.)
128. Mitthl. Chem. (Kletzinsky).
129. Mitthl. Lab. Chem. Brünn.
130. Monatsh. Chem.
131. Monit. prod. chim.
132. Month. Mag. Pharm.
133. Naturh. chem. Notiz.
134. Mag. für Pharm. (Geiger.)
135. Orosi.
136. Penny Mech.
137. Pharm. Times.
    a Chem. Times.
138. Pharm. Centrbl.
    b Chem. Centrbl.
139. Pharmacist.
140. Phil. Mag.
141. Piria.
142. Proc. Am. Chem. Soc.
    a J. Am. Chem. Soc.
143. Proc. Chem. Soc.
    a Q. J. Chem. Soc.
    b J. Chem. Soc.
144. Raccolta fis. chim.
    a Ann. fis. Zantedeschi.
145. [Refer to 37.]
146. Recherches phys.-chim.
147. Recueil trav. chim.
148. Rép. chim. Paris.
149. Rép. chim. pure.
    Rép. chim. appl.
    Bull. Soc. chim. (Paris.)
150. Rép. de pharm. Bruxelles.
151. Rép. de pharm. Paris.
152. Rep. anal. Chem.
153. Rep. chem. Pharm. St. P.
154. Rep. d. Pharm. (Buchner.)
155. Rep. org. Chem. (Löwig.)
156. Rep. Pharm. Russland.
    a Rev. hebd. chim.
157. Rev. Sc. Quesneville.
    a Monit. Sc. Quesneville.
158. Rev. ind. chim.
159. Revista chim.
160. Samml. Abh. Chem. Hochheimer.
161. Scheik. bibl.
162. Scheik. bijdr.
163. Scheik. onderzoek.
164. School Mines Q.
165. Taschenb. Scheik.
166. Techn.-chem. Kal.
167. Techn.-chem. Gewerbebl.
168. Techn.-chem. Jahrb.
169. Tekno-kem. J.
170. Tidssk. anv. Chemi.
171. Tidssk. Phys. Chemi.
172. Tijdsch. wet. pharm.
173. Toeg. Scheik.
    a Maandbl. toeg. Scheik.
174. N. Gegenst. Chem. (Richter.)

175. Unters. Liebig's Lab.
176. Vjschr. techn. Chem.
177. Yearbook Pharm.
178. Ztschr. anal. Chem.
179. Ztschr. chem. Grossgew.
180. Ztschr. physiol. Chem.
181. Zhurnal Khim.
182. Zpravy Chem.
183. Bull. assoc. chim. France.
184. Bull. Chem. Soc. Washington.
185. Chemiker u. Drogist.
186. Chem.-techn. Centrlanz.
187. Deutsche Chem.-Ztg.
188. J. Anal. Chem.
189. Meddel. Carlsberg Lab.
190. N. Y. Analyst.
a Am. Analyst.
191. Skand. Kem. Centrlblad.
192. Suppl. enciclop. chim.
193. Tokyo K. Kaishi.
194. Vjschr. Chem. Nahr.
195. Ztschr. Chem. Ind.
196. Ztschr. phys. Chem.
Am. J. Sci.
Arch. sc. phys.
Jen. Ztschr.
Sitzb. Akad. Berlin.
Sitzb. Akad. Wien.
Phil. Trans. Lond.
Proc. Roy. Soc.
Proc. Am. Acad.
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Proc. Acad. Nat. Sci. Phil.

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